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THE EARTH AND ITS LIFE

THE EARTH AND ITS LIFE

BY

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CONTENTS

CHAPTER PAGE

I. THE EARTH AND THE UNIVERSE . 7

II. HOW THE CRUST OF THE EARTH WAS FORMED—THE PLAN OF THE EARTH 16

III. THE MOVEMENTS AND FASHIONING OF THE CRUST . . 25

IV THE COMING OF LIFE . . 33

V EVOLUTION . . . 42

VI. THE EVOLUTION OF PLANTS . . 52

VII PLANTS AND THEIR ENVIRONMENT . 65

VIII. EVOLUTION OF ANIMAL LIFE—THE LOWER FORMS . . . 75

IX. BACKBONED ANIMALS; FISHES, AMPHIBIANS, REPTILES, AND BIRDS 85

X. MAMMALS 94

XI. MAN 106

XII. THE EARLY USERS OF STONE . . 116

XIII. THE LATER USERS OF STONE . . 126

XIV. USERS OF STONE IN MODERN TIMES . 138

XV. THE USERS OF BRONZE . . 147

XVI. THE IRON AGE . . . 157

XVII. MAN DISCOVERS THE UNIVERSE . 168

XVIII. MAN DISCOVERS THE EARTH . . 184

XIX. MAN AND HIS ENVIRONMENT . . 199

THE EARTH AND ITS LIFE

CHAPTER I

THE EARTH AND THE UNIVERSE

NO single man, if he spent his life in travel, could hope to gain more than an imperfect knowledge of a small portion of the earth's surface. No man, whatever his gifts and industry, could hope to solve a millionth of the problems still unanswered concerning the earth and its life as we know it to-day. No one can say how old it is, yet we know that it is of an age so great that we cannot grasp it. We cannot conceive the slow processes that it passed through before it became a fit abode for life at all, nor the countless succeeding ages during which life was assuming its myriad forms. It took these vast stretches of time and these innumerable stages of development to make the earth and the life on it.

The earth itself is the merest speck in the universe. It belongs to a system of which the star we call the sun is the centre; it depends upon the sun for its light and heat and life. The earth and other planets revolve round the sun, and the whole system, the solar system, as we call it, moves through space.

The sun is one star. There are countless others. Some of these are centres of light and heat like the sun; others are travelling about in space, cold and dark.

In relation to the visible universe the solar system is small; yet the earth is some 93,000,000 miles distant from the sun, and takes a measurement of time which we have called a year to travel round it, while Neptune, an outer member of the system, takes not one of our years, but one hundred and sixty-four, to complete its orbit—that is, the path of its revolution.

THE GREAT NEBULA IN ORION

From "In Starry Realms," by Sir Robert Ball

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Distances in the solar system, then, are so great that the mind cannot grasp them. But they are small compared with the distances that usually separate star from star. For the sun to reach the star that is its nearest neighbour it would take, moving at its estimated speed of about ten miles a second, as far as we can reckon, about 70,000 years, and there is no particular reason for believing that, except in star clusters, the stars are usually closer together than this.

Besides single stars and star clusters, the heavens are sprinkled with luminous smoke-like patches, called nebulæ—*i.e.* fogs or mists. Only a few of these can be seen by the naked eye—the clearest is the faint patch of light round the middle star in the line of three known as the Sword of Orion—but with powerful telescopes about 500,000 are visible. Some of these under the telescope prove to be star clusters—that is, clouds of stars in which the stars appear so close that their light is blent into a common radiance. Others are of very different composition. Some of these are believed to consist of gas so intensely hot that it gives out light, others of luminous solid material surrounded by a darker, cooler, gaseous zone or atmosphere, the latter nebulæ perhaps representing a stage into which the former have passed by cooling. Another theory is that a nebula does not consist of luminous gas, but of countless solid meteorites—those bodies which, entering our atmosphere and heated by the friction of their passage to incandescence, we call shooting stars—which, continually colliding, give off a constant supply of luminous vapour due to the heat generated by collision.

One of the nebulæ visible to the naked eye is the Great Nebula in the constellation of Andromeda. A photograph of it taken by the telescope shows that it consists of a glowing central mass surrounded by a darker outer zone, and that this outer portion is breaking up into rings. There are knots or patches in these rings which may be looked upon as possible future planets, destined to revolve round the glowing centre, which would be their sun. It is probable that the solar system, one member of which is our earth, was once such a nebula, though the exact nature of it is uncertain.

The spinning mass of the sun with its group of spinning planets revolving in their orbits about it, sweeping through space at about ten miles a second, belongs, as far as we can tell, to a star cluster, or cloud of stars, the members of which are comparatively near to one another. The Milky Way, the luminous track across the sky, consists of hundreds of distinct star clusters. The nebulæ are most numerous where the stars are fewest. The solar system, the stars, and the nebulæ make up the visible universe—all, that is, that the telescope brings to our knowledge. Beyond its range there may be a thousand such universes. We have no proof of life on any other member of the solar system. Yet life may be there, resembling the life of the earth, or quite different. There may be life in some form in countless solar systems of countless universes.

The solar system—this infinitely small portion of the visible universe—consists of the sun, eight great planets with their moons, a great number of much smaller planets, certain comets, and innumerable meteorites.

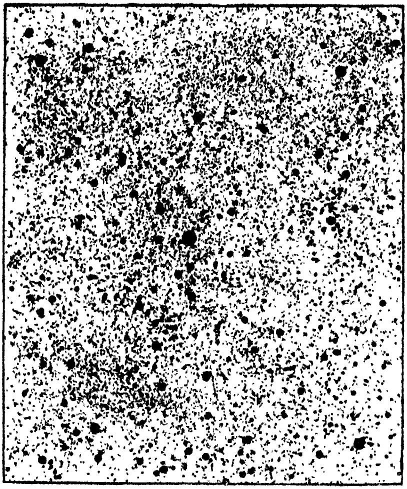
The names of the planets in the order of their distance from the sun are: Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, Neptune. They travel round the sun, and the sun keeps them in their course by the power of gravitation—the force of attraction which all bodies exert on one another in proportion to their mass and the distance between them—the force which we know from experience has to be overcome if we are to leave the surface of the earth, and which produces what we know familiarly as weight.

It has been said that we have no proof of any form of life on any planet of the solar system except our earth. When we consider the possibility of the existence of any life resembling our own, our survey is narrowed.

Mercury is very near the sun, and even if it has an atmosphere it must be intensely hot. Life as we know it could scarcely exist there.

Venus is nearly the same size as the earth. It has an atmosphere and is not too near the sun. Life could exist on it, but its cloud-laden atmosphere would in any case make it impossible for us to perceive on its surface the signs of habitation.

Passing beyond the orbit of the earth we come to Mars. Without discussing the evidence of the so-called 'canals,' life of a kind not too remotely resembling our own is possible here.



PART OF THE MILKY WAY, SHOWING THOUSANDS OF TELESCOPIC STARS

From "In the High Heavens," by Sir Robert Ball. By permission of Messrs Sir Isaac Pitman and Sons, Ltd.

Crossing the zone of the minor planets we come to Jupiter, the largest of the major planets. Jupiter and the rest have but little resemblance to the earth. They are much lighter, much larger, and probably much hotter. It is not certain that they have a solid surface, and they have an atmosphere of clouds that the sun's rays could scarcely penetrate.

Of the materials of which the universe is made we know something through meteorites. These are solid fragments of heavenly bodies, and may be members of the solar system, or enter it from outer space. We see them as meteors or shooting stars when they enter the earth's atmosphere. Till then they are invisible, but as they rush at immense speed through the air friction changes their energy of motion into heat and light. They exist for a moment as luminous vapour before they vanish. Most of them are very small—usually they weigh no more than a grain—but they may be the size of peas, or occasionally much larger. Now and then they enter the atmosphere slowly, escape vaporization, and reach the ground. They have been analysed, and no elements have ever been found in them which do not occur in the composition of the earth. The materials of which the universe is composed would appear, then, to be identical with those which form the substance of the earth.

As far as the earth is concerned, the most important members of the solar system are the sun and the moon.

As has been said before, it is the sun which, by the power of gravitation, holds the earth in its course. By the same power the sun and moon jointly produce those movements of the waters on the earth's surface which we call tides. The sun's heat and light are the sole source of life and energy upon the earth.

The tidal movements due to the gravitational pull exerted on the earth by the sun and moon are not confined to the oceans and seas, though it is on shores bordering shallow seas that they are most easily recognized in the familiar recurrence of high and low water, spring and neap tides. No solid body is perfectly rigid, and it is probable that the solid earth yields to the pull as well as the water, though to a much slighter extent. Again, a solid body having yielded to a stress regains its shape when the stress is removed in proportion to its elasticity.

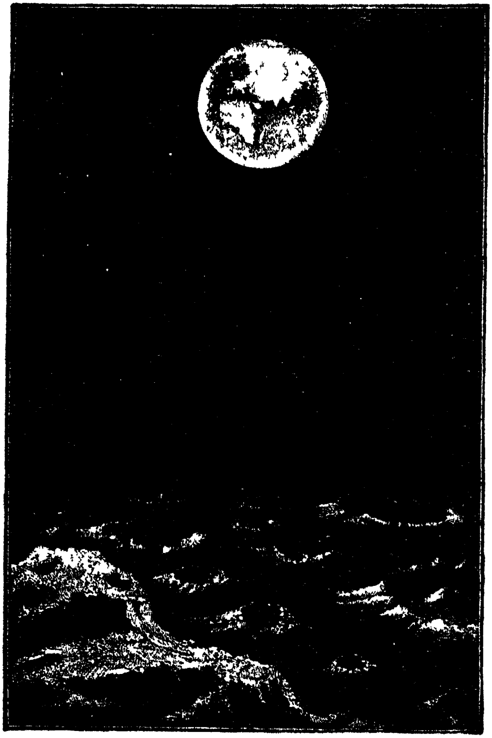
According as the earth, then, is perfectly or imperfectly elastic, it will recover from the deformation due to the tide-causing force.

Moreover, the earth is our time-keeper, a day of twenty-four hours being the time it takes to make one complete turn on its axis, and a year the time it takes to revolve once in its orbit round the sun. The frictional action of the tides, however, very probably prevents the earth from being an absolutely perfect time-keeper, and consequently we cannot be sure that an hour has the same duration as it had a thousand or a million years ago.

Since the life of this planet depends upon the sun's heat, it is obviously a question for us how that heat is maintained.

Supposing that the nebula out of which the solar system was formed was composed of luminous gas, it is exceedingly difficult to understand how it could retain its heat for long. Its material would be so thin that it would rapidly lose its heat by radiation and cease to be luminous. This is what happens when now and then a new star appears in the sky. Something has caused the flaring up of a formerly dark and invisible body—possibly a collision between two dead stars, or the passage of a cool star through a nebula. Great quantities of luminous gas are formed and the new star may be as brilliant as any in the sky. But the heat is soon lost, and in a few weeks the star is again invisible.

On the other hand, supposing the nebula was composed of innumerable solid meteorites, the heat due to collision would produce a constant supply of hot and luminous gas, some cooling and condensing while fresh was formed. Again, though the sun is radiating heat, yet it maintains it by the contraction due to gravity.



MOON CRATERS
The earth viewed from the surface of the moon
From "In Starry Realms," by Sir Robert Ball
By permission of Messrs Sir Isaac Pitman and Sons, Ltd.

Energy in one form—namely, motion—is being converted into energy in another form—namely, heat. It has been calculated that the sun's heat could be maintained by a shrinkage of sixteen inches a day, but there may be other yet unexplored sources of heat in the sun, such as the energy which we know exists in atoms of matter and which is usually imprisoned in them, but may be released and produce heat. The maintenance of the sun's heat would be completely accounted for by the presence in it of a very small percentage of materials resembling radium and therefore called radio-active.

The moon is a satellite of the earth—or the earth and the moon may be looked upon as twin planets revolving about the sun. The moon is a dead planet. She possesses no atmosphere, no clouds, and the face she presents to us shows no sign of the action of water. All we can see is a wilderness of sharp-cut volcanoes which have long been cold. Although the mass of the moon is very small compared with that of the sun, she has more to do with the causing of our tides, the smallness of her mass being more than counteracted by her comparative nearness.

It is known that the earth is infinitely small in comparison with the universe. On the other hand, it is large in comparison with its inhabitants, and its problems are countless and great. There is no true connexion between bulk and greatness, and the infinitely small may contain the infinitely great.

CHAPTER II

HOW THE CRUST OF THE EARTH WAS FORMED

THE PLAN OF THE EARTH

IT is a matter of common knowledge that there are very great variations of temperature on the surface of the earth. There are regions where snow is unknown except on the highest mountains, and where at midday a rock on which the sun's rays have been beating will scorch your hand. There are regions where snow and ice are eternal, so cold that no green thing will live. Yet whether you are at the freezing poles or under a scorching tropical sun, you will find the same temperature a hundred feet below the surface. It is always 52° F. Above this level the variations of temperature are due to the sun; below it the sun's influence does not penetrate. Descend farther and the temperature is found to increase, and increase regularly for any depths to which the thermometer has been carried. This regular increase is 1° F. for every 66 feet of descent—or 80° F. for a mile of descent. Thus at a depth of a little over a mile the temperature would be 132° F.—too hot for us to live in; at a little over two miles 212° F.—the temperature of boiling water. All borings hitherto made, or likely to be made, are quite insignificant in depth compared with the earth's radius Two miles is $\frac{1}{2000}$ of it. Thus we cannot be sure that the rate of increase in temperature is regular for depths much greater than those to which the thermometer has been carried, but we are justified in believing that the temperature does increase and that the interior of the earth must be intensely hot.

When a volcanic eruption takes place masses of molten rock are driven through vents in the earth's surface. The heat of the interior, then, is such as to reduce solid rock to the liquid state when the vast pressure of the overlying matter is removed. In normal circumstances, however great the heat, this pressure is probably such as to prevent the expansion which would accompany liquefaction.

This interior heat, which is great enough to melt rock, increases, as we have said, toward the centre, so that it must be leaking outward, and either the earth is cooling or the heat is being continually renewed.

Where did this internal heat come from ? It has been said that the earth may possibly have had its origin in a gaseous nebula, or more probably in a swarm of cold solid meteorites.

If the earth began as a mass of luminous gas, it should show signs that the oldest climate of which geologists can find evidence was very hot, for the heat would be very great, the crust would transmit it slowly, and cooling would be gradual. But the study of the rocks that form the earth's crust shows that, with local variations (*i.e.* some parts of the earth's surface were hotter than they are now, and some were colder), the oldest surviving layers were formed under much the same conditions of climate as exist to-day.

If, however, the earth was formed by the crowding together of a swarm of meteorites, becoming heated by collision and shrinkage, it would never have had so high a temperature as if it had arisen in a gaseous nebula, and the hot crust would have cooled more quickly.

When the meteorites had all come into contact the mass so formed would go on shrinking, and the motion of shrinking would continue to create heat, which would spread through it until the temperature was the same throughout. The heat would be sufficient to melt some of the materials, but toward the centre they would be kept solid by pressure.

Now the composition of meteorites is known, since fragments have often been found on the surface of the earth and analysed. Many of them are lumps of metallic iron with a small percentage of nickel and earthy minerals of certain kinds. Others consist of earthy minerals of other kinds. They often contain gases, the most important of which are carbon dioxide, carbon monoxide, hydrogen, and nitrogen.

When it is desired to separate the metal in an ore from the earthy materials mixed with it the ore is melted, and the heavier metal then sinks to the bottom of the furnace and is covered by a stony crust composed of the earthy impurities. In the same way the heat of the contracting mass of meteorites would melt the materials in the outer layers of the earth and so bring about the separation of the metals from the earthy constituents, while in the deeper layers the stronger metallic materials would in the process of contraction squeeze out the rest, and thus a metallic core would be formed, surrounded by a rocky crust. We cannot prove the existence of this metallic core by access to it, but it is made more probable by the fact that the earth weighs more as a whole than would be the case if the interior was composed of the same materials as the surface rocks. An interior composed chiefly of metals would account for this. There is other evidence leading to the same conclusion, and we may regard it as almost certain that the earth consists of two main parts · a stony crust and a heavy metallic core.

The increase of temperature as we approach the interior of the earth shows that the earth is losing heat outward, but, as has been said of the sun, there is no good reason to suppose that the earth is cooling. Shrinkage no doubt goes on, though at a continually slower rate, but this is not the only source of heat. Heat may be continually created n

A CARBONIFEROUS FOREST

the interior by chemical energy in materials that are radio-active.

As the crust formed and cooled, the water which had been present in vast quantities as vapour in the earth's envelope of gases condensed and occupied the hollows in the surface. These became the ocean basins, and the higher regions the continents, and thus the division into land and water took place, roughly five-sevenths being water and the remaining two-sevenths dry land. Round the globe the envelope of gases formed an atmosphere.

There is enough water in the oceans to cover the whole globe, if the surface were made even ; possibly when it first condensed it did so cover it. Had it continued to do so, the history of the earth would obviously have been very different. But the earth is continually shrinking, the interior more quickly than the solid crust, and while it was still young and shrinkage most rapid the crust would begin to accommodate itself to this diminished interior. After an apple has been picked some time it begins to grow dry and lose bulk, and the skin, which has become loose, wrinkles itself in order to fit it. In the same way, while the crust of the earth was still thin it crumpled everywhere to keep pace with the lessening bulk inside. Thus a division of the surface into land and water would take place, but the arrangement would clearly be very different from that which exists to-day. Later on when the crust was thicker the crumpling took place only in the weaker areas, and as shrinkage proceeded great portions of it sank and formed shallow depressions. Thus the earth to-day is a globe slightly flattened on four faces, and these hollows are occupied by the four great oceans

Whether the four great depressions have always existed, causing the distribution of land and water to resemble that of to-day, is an interesting investigation, and geologists have not all come to the same conclusion. It is quite certain that many parts of the earth have been dry land at one time and sea at another; nearly all England, for example, has been many times submerged by the sea and uplifted again. What is not established is whether these interchanges of sea and land are confined to the neighbourhood of shallow seas and to the margins of the ocean basins. Some lands at any rate, among them Labrador, Scandinavia, some part of India, and much of Africa, have never been entirely covered by the sea during geological time. Yet the distribution of animals and plants leads us to think that the arrangement of land and water has differed greatly at different geological periods.

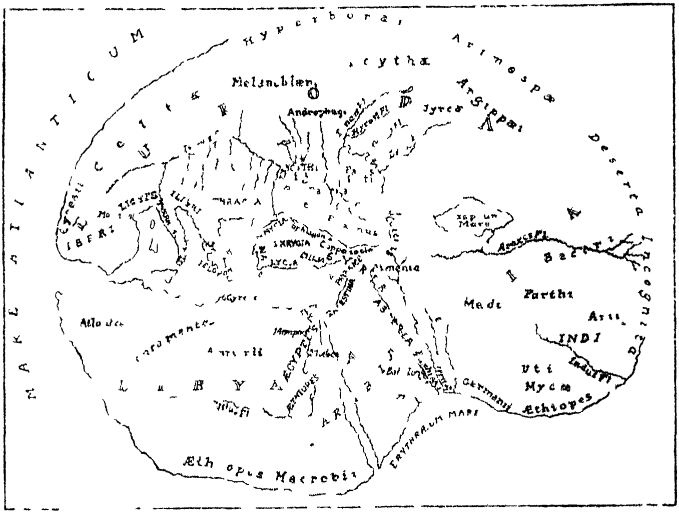
We can see as we examine a globe or a map of the world that this arrangement follows a definite plan. Even the earliest geographers were impressed with this, though their knowledge of the earth's surface was too limited for them to come very near the truth. The classical geographers imagined that the Mediterranean basin was the centre of a wheel-shaped island bounded by one vast ocean. The medieval geographers drew the lands of the globe radiating like spokes from Jerusalem as a centre. From a modern globe or map we shall see that the plan of the earth has four main features:

1. The Northern Hemisphere contains the greater part of the land and the Southern Hemisphere the greater part of the sea.

2. The lands form nearly a complete circle round the Northern Hemisphere and stretch southward in three

pairs of continents: North and South America, Europe and Africa, Asia and Australasia. The oceans form a complete circle round the Southern Hemisphere and stretch northward.

3. Most of the lands and seas are irregular triangles.



THE WORLD ACCORDING TO HERODOTUS

The lands taper southward, and in consequence the seas taper northward

4 Land and sea are antipodal—that is, a line drawn from a land surface to the centre of the earth and continued till it reaches the surface again is almost certain to have sea at the end of it. Thus the Arctic Ocean is antipodal, or opposite, to the Antarctic continent. Europe and Africa are antipodal to the Central Pacific, and so on.

The arrangement of land and water has a very close connexion with the habitability of the globe Lands depend upon moisture for their fertility, and the oceans are the reservoirs from which their water supply is replenished by the agency of rain-bearing winds. Since the winds are drained of their moisture as they pass over the land, any region situated too far from the sea is desert. An alternation of land and sea will therefore render a much larger proportion of the land surface habitable than if all the land had formed one vast continent and the water one vast ocean.

If we speculate about the appearance of the infant earth, when its crust had solidified and cooled sufficiently to allow the water in the atmosphere to condense upon its surface, we may imagine a tumbled confusion of hills and valleys still warm and moist, warm, stagnant seas, not yet salt, not yet ruffled by the winds that we know to-day, and, wrapping it round, an atmosphere laden with carbon dioxide and thick with clouds, scarcely to be penetrated by the sun's rays. Under this cloud-screen the temperature would vary hardly at all, day or night, summer or winter. It would be a grey earth under such a sky, with no sunshine to bring out the colour of the distorted rocks. Not an atom of living green would be visible, for no life such as we know it could exist when the primeval crust was solidifying out of molten matter. It would take ages of preparation before the earth could be fit for the most primitive form of such life. Before it appeared the original rock surface would have to be broken down by destructive agencies existing from the beginning and working from the beginning, and rebuilt into new rock layers under whose pressure the solidification of the deeper-seated rocks would proceed. As the contraction of the globe, more rapid in the interior, went on, fractures would occur in the crust and parts of it sink, and the added pressure on the softer rocks beneath would drive them to escape through the vents, liquefying as the pressure was removed, in volcanic eruption. Once on the surface they would be exposed to the same destructive agencies as the older rock. Running water was already at work. Acid gases were present in the atmosphere; and when the sun could penetrate the screen of clouds it would start the winds blowing, the waters circulating, and give the earth its seasons. All that was necessary for the fashioning of the earth and the development of its life was already in existence. But the germ of life had yet to appear, and the preparation was long before the earth was fit to receive it. The preparation and the development as we see it to-day have taken perhaps a hundred million years.

CHAPTER III

THE MOVEMENTS AND FASHIONING OF THE CRUST

NO life as we know it existed in the infant earth, but the materials necessary for life in every form from the humblest to the highest were there, in the rocks, the water, or the air. Only as yet they were useless; they were scattered here and there in minute quantities, or locked up at great depths, or in a form that would have to be broken up before its materials could be usefully employed. Much preparation of the crust was essential before the germ of life could thrive, and then life in its lowest form had to smooth the way for a higher stage.

It has been said that the original rocks of the crust had to be broken down and reformed, and that the agents which could carry out this work were in existence at the very beginning of the solid earth. It would be the higher surfaces of the rocks that would be most exposed to destructive agencies, and, once broken down, wind and water would transport them to lower levels and lay them down in horizontal sheets. By themselves these processes would in time result in the reducing of all land surfaces to sea-level; they are counteracted by uplifts and sinkings in the crust itself and by balancing movements in adjacent areas.

As regards the latter, it would seem that the additional weight of a new layer of rock *débris* causes the area on which it is deposited to sink, while the neighbouring land from which it has been removed is lightened and enabled to rise. The wearing-down processes continue on the newly raised land and fresh layers are transferred to the lower levels. These presently sink again and the areas lightened by what is called denudation again rise.

Movements in the earth's crust produce mountains. Sometimes weaker areas of the crust collapse, leaving blocks of stronger rock standing above the level of the surrounding country. These blocks are attacked by the agents of denudation, heat, frost, wind, rain, and the gases in the air, and then the surface crumbles and becomes jagged. Rain lies in its hollows, trickles down its sides, and washes away the loose fragments of the rocks. In time deep valleys are worn in the mass along which streams or rivers rush, for ever widening their beds, and the parts left standing between them form mountains.

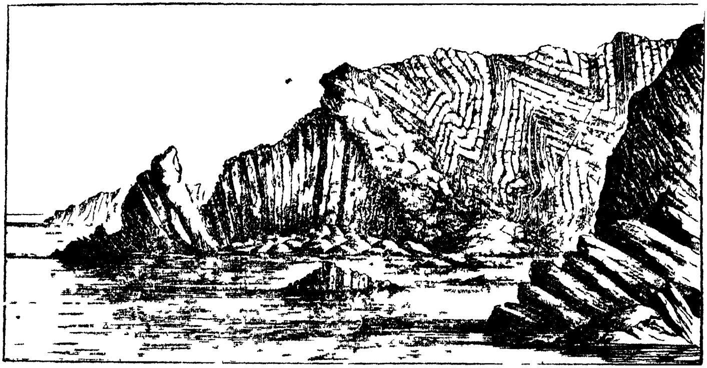
Other mountains are formed by the crumpling of the earth's crust into parallel ridges and valleys. Others, again, are uplifted in dome-shaped swellings by the inflow underneath them of rock still plastic with the heat of the interior.

Volcanoes are vast heaps of once molten rock and ash piled up round the vents in the earth's crust through which their materials were driven.

The uplift of the land continually exposes fresh surfaces to the forces of denudation. Very often these surfaces consist of primary rock, rich in materials necessary for the development of life, but hitherto inaccessible. It is the work of denudation to set these free by breaking down the rock so that it may be transported by wind and water and refashioned as a secondary rock in which these valuable constituents have become available.

The chief agents of denudation are the oxygen and carbon dioxide in the air, rain, heat, frost, and wind.

Oxygen combines with some of the constituents of rock. These expand with the heat of combination and thus loosen others, and the rock begins to decay and crumble. The destructive power of oxygen is easily seen in the rusting of iron, which loses its surface in flakes as a result of exposure to the atmosphere.



CONTORTED SILURIAN STRATA

From 'Secrets of the Hills,' Craig (Harrap)

Carbon dioxide is dissolved from the air by rain; the rain penetrates the rocks and the carbon dioxide in it combines with some of the constituents and forms carbonates. This process usually results in the slow decay of the rock; moreover, the carbonates, as, for example, calcium carbonate, of which limestone is formed, are easily dissolved by water containing carbon dioxide, and a limestone country is characterized by deep gorges and caverns which streams and rivers have excavated. The Cheddar caves and the caverns of the Peak district have been made in this way.

Rain soaks into the pores of the rock and washes the loose fragments from the surface. Wind beats upon it, laden sometimes with grains of sand, grit, and dust which it has carried from elsewhere, and so helps the grinding-down process.

Heat causes rock to expand. As it cools again it contracts, and the alternate expansion and contraction weaken its structure. Frost, again, causes the expansion of water in the pores and crevices, and as a result the rock splits and is laid more open to the destructive forces of air and water.

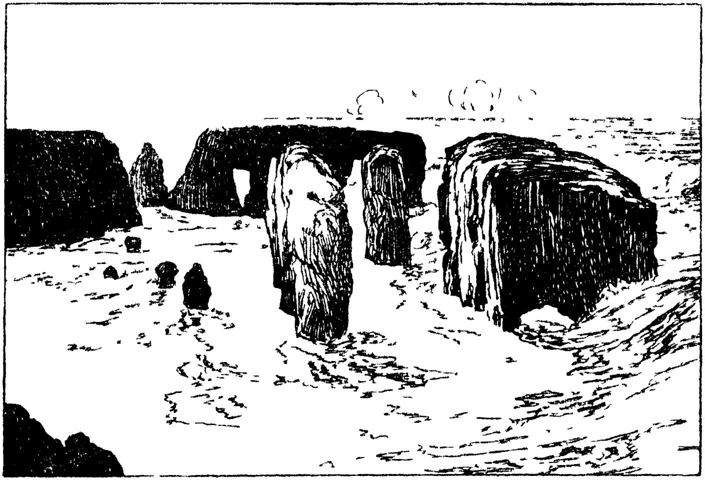
Wind and water are the chief agents in laying down beds of secondary rock with the materials of primary rock thus broken up. Wind carries away the lighter particles and deposits them in a sheltered spot; mountain torrents bear along boulders loosened from the mountain-side, as well as pebbles, sand, and mud. As the speed of the current lessens the *débris* is deposited according to its size: first the boulders, then the pebbles, then beds of sand, and lastly, when the current is slowest, sheets of mud. Thus a river destroys in its upper course and builds up in its lower.

Sandstones, clays, limestones, and coals are the chief kinds of secondary rock.

Sandstones are composed of grains of sand which have become cemented together. They provide valuable building stone.

Clays are composed of the finest water-borne particles. They are deposited as mud and converted by pressure into rock. Besides furnishing material for building bricks, they decay into rich soil. and as they are impervious to water, beds of clay act as reservoirs, from which water is discharged in springs or from which it can be obtained by sinking wells.

Limestone may be formed by the deposit of the calcium carbonate often carried in solution by springs and rivers. Usually, however, its formation is a more complex process. It is extracted from the water by organisms which use it to build up their shells and skeletons. When they die these parts lie on the sea floor and the accumulation may be cemented into limestone. The limestones make fertile soil and also provide building stone and cement.



'STACKS' HARD PARTS OF THE CLIFFS LEFT STANDING AFTER THE SOFTER PARTS HAVE BEEN WASHED AWAY

From "Secrets of the Hills," Craig (Harrap)

Coals are due to the action of plants. These extract carbon dioxide from the air and use the carbon to build their tissues. When masses of decaying vegetation collect in swampy beds they form peat, and if the peat is buried under fresh rock deposits and subjected to heavy pressure it is slowly converted into coal; and so we get fuel from material existing in the air, but to be obtained from it only by the agency of plants.

Beds of salt are found when lagoons or arms of the sea have dried up, and the saltness of the sea is due to rivers, which have been washing salts out of the soil and carrying them in solution to the sea for many millions of years.

STALACTITES (LIMESTONE DEPOSITS)

From "Secrets of the Hills," Craig (Harrap)

The areas built of secondary rock will, it is clear, be the areas most useful to man, but they need continual refertilization, as the constituents required by plants for their food are extracted by them or carried away by rivers. These constituents are washed down from the primary rocks of the mountains, or carried by the wind over wide areas in volcanic dust, or provided by the decay under denudation of the volcanic rocks themselves.

Great clouds of gas and steam are mingled with the molten rock in a volcanic eruption. The hot waters dissolve some of the metals with which they come in contact, and when they cool the metals, which had before been too scattered to be useful, are deposited as mineral veins, from which they can be mined.

The last stage in the breaking up of both primary and secondary rock is the formation of soil, which is the topmost layer of the earth's crust. It is the rock in its final condition of decay, the agents of which are chiefly water and the gases of the atmosphere. To-day burrowing animals and earthworms and the roots of plants are always helping the work of pulverization. Soil, however, had to be formed before the higher plants could exist at all, since they must have a layer of loose material into which they can thrust their roots and fix themselves to the ground. There must be soluble plant food too, for plants can take only in solution that part of their food which comes from the soil. They have the power of obtaining carbon from the carbon dioxide in the air and using it to build up the carbon compounds in their tissues. Nitrogen, another essential element in plant food, exists as a free gas in the atmosphere, but cannot be assimilated by plants in that form. They must obtain it from mineral nitrates in the soil. The formation of these is aided by minute and primitive organisms known as bacteria. The plant uses the nitrogen from the nitrates in building up products which can be assimilated by animals, for animals are dependent upon plants for nitrogenous food, as well as for carbon compounds.

As soil, which is rock broken down to the uttermost, is essential to plants, and as without plants there could be no animal life, it is the soil which is the first source of our food supply, and on which all life depends. It is the end finally reached by the once molten rock of the earth's crust.

No life, as we know it, could exist when the primary rocks were solidifying from the molten state. Evidence of the different types of life that came into existence later is found in the secondary rocks that were being formed when they lived and in which they were buried. Type succeeds type, the lower giving way to the higher, or surviving alongside it because of some necessary function that it fulfils. The higher forms of life were possible only because the more primitive preceded them and prepared their way.

CHAPTER IV

THE COMING OF LIFE

IT has been said that secondary rocks contain the remains of the animals and plants which were living at the time that they themselves were being laid down. These remains are called fossils. The oldest fossils that we possess, however, are those of plants and animals which must have had a long line of predecessors. They are the fossils of plants and animals with hard parts—animals with shells or skeletons, and plants with woody stems. Such parts are not found in primitive organisms. They are adaptations of structure to meet a change in environment. Shells, for example, are defensive armour evolved—we cannot tell by what stages—to resist the attacks of an animal that has become carnivorous. Skeletons give the power of swift movement, which has become necessary so that their possessors may escape from enemies or pursue a prey. Such specialized organisms must, it is clear, have been preceded by simpler ones, and the soft tissues of the earliest organisms would not be preserved as fossils, even if the mud on which they were formed had not in all probability been destroyed by the unresting forces of denudation and rebuilt into new rock. We cannot then expect to find in the earth's crust records of the earliest organisms, but there are in existence at the present day organisms so simple that we may believe that the earliest forms of life resembled them. As to the manner in which life itself originated we can at present only form theories.

So far we have spoken of life without feeling the necessity to define what we mean by the word, because every human being with the power of thought recognizes life as something existing in himself. He is aware of it in that very faculty of thought—that is, in his consciousness. When, however, we come to define 'life,' to distinguish between what is organic or living, and what is inorganic or non-living, we shall find it a difficult matter. We shall be reduced, in fact, to stating some of the characteristics of life without saying what life *is*.

Does life reside in consciousness—that is, in the faculty of thought? We know that this faculty exists in ourselves; we assume that it exists in other people whom we see acting in given conditions in similar ways. But as we descend the scale of life we see less and less of what we can interpret as thought, and in the lowest forms of life it does not appear to exist at all. If all life evolved from some simple organism, it is more probable that consciousness developed gradually, as the forms of life became more complex, than that it is always associated with life.

Living things—that is, plants and animals—take in food. They keep what they need to build up their tissues and reject what they cannot use, and the result is growth. But mineral crystals also grow; they take from solutions what they can use as food and leave what is useless to them, so that the absorption of food and the function of growth do not mark off what is living from what is non-living.

Organisms, however, it may be said, absorb food internally and have an inner growth, while crystals are built up on the outside, and this is a general distinction between living and non-living matter. Yet there are some inorganic bodies which also have inner growth and which under mechanical stresses produce forms which have a strong resemblance to the leaves and stems of vegetable life.

Changes of structure and composition, it has been said, take place in a living individual without its losing its identity. The same is true of the growth of crystals, successive layers of which may be different both in composition and structure, and yet the crystal retains its form and is recognizable as the same.

Living bodies have the power at a certain stage of growth of dividing into, or producing, smaller bodies which display the same characteristics. Crystals also have a limit of size, and when that is reached, if fresh material is deposited on the surface, a younger generation of crystals is formed, growing on the same lines as those that preceded them until they reach their greatest size, when they too produce a fresh generation.

So far, then, we have not found any satisfactory line of cleavage between what is living and what is non-living.

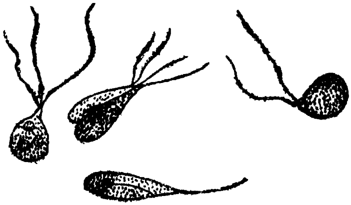
Inorganic matter has no consciousness. But consciousness is not found in all forms of life.

Crystals as well as living bodies take in food and reject what is useless in it, grow, and have the power of reproduction, and undergo changes in structure and composition without losing their identity.

It is difficult, then, to *define* the difference between the living and the non-living, so difficult that we are forced to give up the attempt to do so and must try to *describe* life by its characteristics.

The substance of living things is a jelly-like material called protoplasm. This consists of very complex compounds of carbon, hydrogen, nitrogen, sulphur, and oxygen, together with water, and it is not found except in living bodies. Some of its simplest constituents can be made by chemists artificially, but the artificial manufacture of protoplasm is not yet possible, and there appears no probability of its being obtained except from living substances.

Living things show a successive change and development, leading to the decay of the individual; but during this development the individual is renewed by some process of reproduction or division.


SWIMMING PROTOPLASM

Life gives the power to receive from food a supply of energy and the power to do work.

Life requires a special environment. Certain conditions of temperature and moisture must be provided if it is to survive.

Living things grow by food different from themselves.

Living things adapt themselves to their surroundings in a way that tends to self-preservation.

By these characteristics, which are not shared by inorganic matter, we can distinguish what is living from what is not living.

All forms of life must have evolved from the simplest possible organism—a drop or grain of protoplasm.

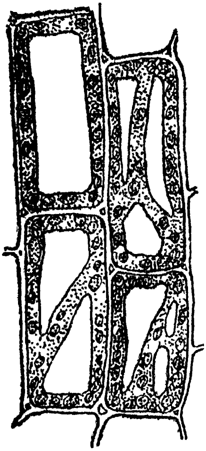
Now, as has been said before, many millions of years ago the temperature of the earth was such that no life, such as exists, to-day, not even a grain of protoplasm, could have existed. How then did life come to the earth ? We do not know. We can only form theories.

Some authorities have held that life is as old as matter. If this be so, protoplasm, which, as it now exists, is a highly complex substance, probably passed through a series of simpler stages ; and in these stages it must certainly have been able to withstand conditions of temperature which, as far as our knowledge goes, it cannot now endure. Otherwise the grain of living protoplasm must have reached our earth when it had cooled and solidified sufficiently to be a fit abode for life. It has been suggested that it may have been carried in the crevice of a meteorite—that is, what we call a shooting star. Protoplasm, however, can withstand extremes neither of heat nor cold, and a meteorite would be exposed first to the intense cold of outer space and then to intense heat, due to friction, as it passed through our atmosphere. Moreover, we have no reason to assume that the conditions of the early earth were not as suitable for the first development of life as those of any other of the heavenly bodies.

It may be that living matter evolved in favourable conditions from non-living matter very long ago, but after the earth had passed from a stage in which life could not exist. At the present day, as far as we know, there is no generation of living from lifeless matter, but it is possible that there were as many stages between the non-living *material* of life and the living protoplasm as there have been between the protoplasmic grain and the myriad forms of life that evolved from it. If it be true that life was evolved from the lifeless matter of the earth's crust, then it is in a literal sense true that man is made of the dust of the ground, since he is the culminating point of the many-branched tree of life that sprang from it.

What were probably the conditions on the early earth that led up to the wonderful day when life was born ?

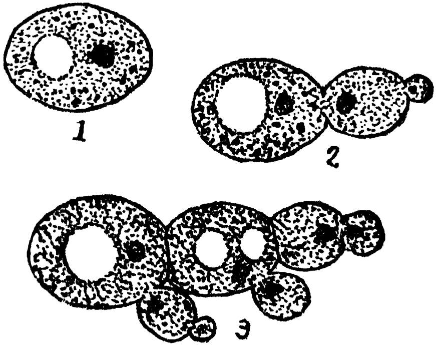
The surface was warm and moist, and owing to the density of the atmosphere the temperature would probably vary very little day and night all the year round. While the earth was hot enough to be incandescent various nitrogenous and other compounds would be formed which would readily break up and form new combinations. When the water was condensed upon the surface of the earth it would contain in solution materials from the earth's crust and also gaseous compounds of carbon, nitrogen, and phosphorus from the atmosphere. The water with its dissolved salts and gases would saturate the mud along its shores, which in temperature and moisture would provide a suitable environment for the protoplasmic jelly. Sunlight would provide the energy necessary for the breaking up and recombination of the mineral salts and carbon compounds, and thus might originate very simple living substance, developing by slow stages into protoplasm.



PROTOPLASM ENCLOSED IN CELLS

The simplest organisms consist of single cells—*i.e.* of a minute amount of protoplasm surrounded usually by a skin or cell-wall. Some organisms have remained in this stage; all arose from it, and one of the greatest steps in evolution was that from single-celled to many-celled organisms.

Some single cells combine with others to form a many-celled body. Here there is no development of cell from cell. Cells subdivide owing to the influence of their nucleus, a more compact mass of protoplasm in the centre, an essential constituent of which appears to be phosphorus. Without this cells may live, but they do not subdivide. Sometimes the nucleus divides again and again within the cell, so that an organism with many nuclei is formed. Sometimes the nuclei break the wall and begin a fresh life as single-celled organisms. Many-celled organisms, or bodies, were probably formed as the result of a failure to achieve this separation. When the stage of growth arrived at which division into two or more separate organisms usually occurs the nuclei, unable to break out and start an independent existence of their own, remained in association with the mother-cell and originated a growing cellular structure or body. It was a great stage in evolution which associated life with a body, for it was the beginning of all the different forms of life.



Reproduction by budding in a Single-celled Plant (Yeast)

1, an adult cell; 2 and 3, stages in budding in which new outgrowths from the mother-cells produce daughters. These grow up and may become independent or remain attached in a chain.

From "Biology of Sex," Galloway (Heath)

The simplest of all living creatures are called by Haeckel 'protists.' We do not know how close to or how far from the first organisms they are, but they are like them in this, that they are neither distinctively plants nor animals. Gradually the life of the world divided into these two main streams. The protists, as it were, have never been able to make up their minds to which stream they belong.

When we considered what we meant by life we found that the distinction between organic and inorganic was not as clear as we should have expected, and while we were conscious of a profound difference between the two we discovered resemblances which were almost as striking. In the same way we shall find important resemblances and marked differences between plants and animals If we investigated sufficiently far we should find the one branch of life merging into the other by stages so subtle that at last we could not say, "This is plant," or "This is animal."

Plants and animals alike breathe, feed, digest, grow, have families, and die. They are alike in being built up of cells and modifications of cells, all originating in one fertilized egg-cell.

They are totally different in the way they obtain their food. All the materials necessary for the food of both exist in the air, water, and earth. For everything except water animals are dependent directly or indirectly upon plants. The carbon and nitrogen they require they obtain, not from the air or the soil, but from complex organic compounds built up in plants or in other animals who have obtained their materials from plants. Plants get their carbon from the carbon dioxide of the air; in the presence of sunlight this is built up within their tissues into various carbon compounds. Their nitrogen they take in by their roots in the form of nitrates in solution. Sun-energy is used by the plant in building up complex food-stuffs which contain potential chemical energy. The animal eats what the plant has stored up. He breathes—that is, takes oxygen into his lungs. Within his frame the oxygen combines again with carbon and hydrogen and is given out as carbon dioxide and water. The potential energy stored in the plant-food is set free within his body in the form of animal heat and animal motion—*i.e.* locomotion and other forms of activity. The animal has spent the sun-energy stored up by the plant. The relations existing between plants and animals, plants being storers of energy of which animals are the consumers, lead to one of the great distinctions between plants and animals. Animals in general are more active than plants; and again, because of their dependence upon plants for food, animals need the power of free locomotion.

It is unnecessary after this to ask which came first, plant or animal. No animal could exist until plants had first prepared stores of food for it. The earliest living organisms were indistinguishable as plant or animal until some of them began to manufacture chlorophyll, the green colouring matter of plants, without which they cannot build up the complex carbon compounds that animals require. The main outward sign of a plant is that it is green, and this it owes to chlorophyll, the production of which made possible the life of plants, and through them of the lower animals and man.

CHAPTER V

EVOLUTION

SINCE this globe, this earth of ours, moulded into every variety of surface, crowded with innumerable forms of life, arose in dim, unimaginably remote ages in a nebula, and passed through a stage when it was fluid and so hot as to give out light, it is clear that it has undergone constant and continuous change. It is still undergoing it. This orderly change and development, not only in the earth but in the universe, in the smallest things as well as in the greatest, in the present as well as in the past, in the earth's crust, in plants and animals, in the minds of men, and consequently in their laws and customs, and in their struggles to maintain themselves upon the earth and to become masters of their environment, we call evolution.

We are constantly seeing evolution at work both in history and in everyday life. We can trace, for example, the development of the modern English Parliament from the Witenagemot of the Saxon kings, or that of the modern trade unions from the medieval gilds of craftsmen. We can see before us in the course of a lifetime or from models in museums the evolution of inventions which sprang from the minds of men. Every change of construction is intended to bring about an improvement in some part where the original invention was weak, and the new forms either have to establish themselves as better than the old or they are soon relegated to the scrap-heap. Thus we can follow the steps by which the velocipede or 'bone-shaker' became the modern bicycle, the first armoured vessel the latest super-Dreadnought, and Stephenson's "Rocket" the present-day locomotive engine.

Again, we know that if a gardener wishes to produce a new colour in a certain flower he takes his seeds from the plants which approach most nearly to it, and raises his seedlings from these. When the new generation of plants is in flower he again selects those individuals for his experiments which show perhaps a deeper shade of the desired colours, and by repeating this process many times he can usually attain his end. In this way a new variety is produced as a result of the deliberate selection by the grower of the plants from which to take seed.

Because such facts as these are familiar to us, and because the doctrine of evolution is part of the thought of educated men at the present day, it is surprising to find that it has been generally held for not much more than half a century.

It is true that we find in the writings of certain Greek philosophers as early as the seventh century B.C. allusions which show that they possessed an inkling of the principles on which the modern theory of the universe is based. Their teaching, however, was vague, because it could not be founded on that detailed knowledge of nature which it took more than another two thousand years to gain, and which required the invention of scientific instruments. Thus when, at a later date, Heraclitus says, "All is flux"—that is, "All is change"—we assume that he had grasped that idea of the ceaseless development of the universe which we call evolution, but we cannot be sure of it.

Again, another Greek philosopher, living more than five hundred years before Christ, had sufficient insight to declare that the fossils of plants and animals found in rocks were the actual remains of formerly living creatures, and that the rocks in which they were found must have stood at some time under water. Yet throughout the Middle Ages and even down to the eighteenth century the most absurd ideas prevailed as to the nature of fossils, as, for example, that they were produced by the influence of the stars, and thus the illuminating knowledge was missed that in the fossil remains of plants and animals preserved in the earth's crust, the comparative age of which can be estimated by the depth of the rock layer in which they are found, we have a wonderful record of the successive forms of life that have existed on the earth since it became a fit abode for life at all. The great painter Leonardo da Vinci in the fifteenth century stated the truth about fossils, but in this as in other matters he was too far in advance of the age in which he lived to gain many followers. Moreover, the Inquisition made it dangerous to announce new theories in Roman Catholic countries. In 1600 the Dominican friar Giordano Bruno was burnt at the stake in Rome for expressing evolutionary ideas about the universe, and in 1633 his countryman, the great astronomer Galileo, was three times summoned for examination before the Inquisition, and forced under threat of torture to recant similar convictions.

As late as the eighteenth and early nineteenth centuries people in general held much less enlightened views concerning the making of the earth and the development of the life on it than those of some thinkers among the Greeks more than two thousand years earlier. Early in the nineteenth century the great French naturalist Cuvier published a famous work on the fossil bones of backboned animals. In this he states that the extinct species of animals whose remains are found in the different layers of the earth's crust differ the more strikingly from the living species of animals akin to them the deeper those layers lie—that is, the more remote the ages in which those animals lived. This, of course, is true and what we should expect, since the fossil animals are the ancestors of the present living animals, or the representatives of kindred lines which became extinct. Unfortunately Cuvier wrongly believed that the same species were never found in succeeding groups of rock layers, and he therefore held that a series of unexplained catastrophes had periodically destroyed the whole world of animals and plants and that at the beginning of the next period a new and improved population of living things had appeared. With these ideas the majority of people were satisfied. Yet evolutionary ideas were in the air, and in the early years of the nineteenth century we find Englishmen such as William Charles Wells and Patrick Matthew, Germans such as Goethe, Treviranus, and Oken, and Frenchmen such as Geoffroy Saint-Hilaire and Jean Lamarck all publishing theories of the origin of life and species corresponding with modern views on the subject. Of these Lamarck developed his theory most fully, in works published in 1801 and 1809, and he was so much in advance of his age that they were understood by few and disregarded by the world for fifty years.

In 1830 the way was paved for the man who was to win general acceptance for the evolutionary theory of the universe by the publication of Lyell's *Principles of Geology*. In this he showed that Cuvier's theory of unexplained catastrophes changing the surface of the earth and wiping off the life on it was unnecessary and unfounded; that the very same causes which are at work to-day, such as rain, wind, heat, frost, and imperceptible risings and sinkings of the earth's surface, acting for millions of years, are sufficient to account for the present formation of the earth's crust, and, without colossal volcanic eruptions, to raise the highest chains of mountains.

Lyell's work entirely destroyed the theory of catastrophes, and yet it continued to be assumed that the whole plant and animal world was recreated at the beginning of each new period of the earth's history. It was the great English naturalist Charles Darwin who succeeded in establishing the truth that the plants and animals of to-day have arisen from lower living forms by such slow and continual changes as have produced the present various features of the earth's crust from earlier and different ones. It was not only that when he wrote the times were ripe and men's minds prepared for the acceptance of the theory of evolution. Darwin, besides treating the views put forth by Lamarck and others much more fully and clearly than they had done, gave in his doctrine of natural selection an explanation of the changes in living things, whereas his predecessors had merely stated them as facts. The reasoning on which he based his theory is not universally accepted at the present day, but it brought home to men's minds, as nothing before had done, conclusions which are everywhere acknowledged as true.

It was in 1858 that Darwin published his *Theory of Natural Selection*, which was carried out in greater detail in *The Origin of Species*, 1859. Spencer, Huxley, Haeckel, and many others had been working on the same lines, and Alfred Russel Wallace reached the same conclusions as Darwin on natural selection and published a treatise on it at the same time. *The Origin of Species* was the result of twenty years' labour, from Darwin's voyage as naturalist in the *Beagle* (1831-1836) to the date of publication. The following extract from the introduction is worth quoting for the light it throws on scientific method:

"When on board H.M.S. *Beagle* as naturalist, I was much struck with certain facts in the distribution of the organic beings inhabiting South America, and in the geological relations of the present to the past inhabitants of that continent. These facts . . . seemed to throw some light on the origin of species—that mystery of mysteries, as it has been called by one of our greatest philosophers. On my return home, it occurred to me, in 1837, that something might perhaps be made out on this question by patiently accumulating and reflecting on all sort of facts which could possibly have any bearing on it. After five years' work I allowed myself to speculate on the subject, and drew up some short notes; these I enlarged in 1844 into a sketch of the conclusions, which then seemed to me probable: from that period to the present day I have steadily pursued the same object. . . . My work is now (1859) nearly finished; but as it will take me many more years to complete it, and as my health is far from strong, I have been urged to publish this Abstract."

It was, then, what he saw in South America and in the Galapagos Islands, 600 miles distant from the west coast, that caused Darwin to conceive that new theory of the origin of species which he spent so many years in patiently testing and working out. The view of species commonly held at the time was that each had been separately created. Darwin maintained that many of the so-called species were merely variations of an older common stock, that in remote epochs these stocks were fewer and resembled each other more nearly, and that the failure in many cases to trace the intermediate links between existing and extinct types, or to verify the existence of a parent stock from which types strikingly diverse in appearance had nevertheless sprung, was due not to their non-existence, but to their having for various reasons failed to survive in fossil form. The causes of variation he maintained to be not only external conditions such as climate, food, etc., but the working of natural selection, those individuals of a species and those species in general having the best chance of surviving which were best fitted to their environment.

During his visits to the different islands of the Galapagos group, now divided from each other by deep arms of the sea, and 600 miles distant from the mainland, though perhaps formerly connected with it and each other, Darwin was much struck by the fact that each island had plants and animals, especially reptiles and birds, which, in spite of the special facilities of the latter for migrating from one island to another, were peculiar to it, though in many cases species were common to more than one island, and nearly every island had species in common with the neighbouring American mainland. Moreover, the closer the islands were to one another the more resemblance there was in their plants and animals. This was unintelligible unless it meant that corresponding species on different islands had a common descent, and that the differences had been produced by changes in environment.

Again, by comparing the living animals of the continent with fossil remains, he found a striking resemblance between the existing animals and the extinct, the conclusion being that they were blood relations sprung from a common stock.

Armed with these facts, Darwin came home in 1837 to collect all the facts he could find bearing on the theory he had formed of the origin of species by natural selection, to weigh the evidence, and to draw up his conclusions.

He first carefully studied instances of variation in domesticated animals and plants. He gave great attention to domestic pigeons, and came to the conclusion that in spite of the wonderful diversity of the different breeds—carrier, tumbler, runt, barb, pouter, fantail, turbit, Jacobin, etc.—they were all descended from the rock pigeon, and that their peculiarities were produced by the deliberate adding up of variations given by nature—that is, by the mating of a bird displaying a certain peculiarity with another possessing the same. He considered what was being done every day to produce rapid variation in the breeding of horses, cattle, and sheep, and in the cultivation of plants. The greater variability of domesticated animals and plants compared with that of the same in the natural state he decided to be due to changes in the conditions of life and to more abundant food.

Turning to variation under nature, Darwin found its origin in the struggle for existence. Variations, he says, if they be in any degree profitable to the individuals of a species, will tend to the preservation of such individuals and will generally be inherited by their offspring, which in their turn will have a better chance of survival. This principle, to mark its relation to man's power of selection, Darwin called natural selection; Herbert Spencer described it by the expression, the "survival of the fittest." The struggle for existence is due to the fact that all living beings tend to increase at a higher rate than the means of life will support. In nature, therefore, there must be great destruction and waste. Out of a hundred seedlings produced by a plant only one may reach maturity, because they must all compete with other plants for light and air and the food contained in the soil Again, each new variety or species that is undergoing improvement presses hard on its unimproved kindred and tends to exterminate them because it is better equipped for the struggle to obtain food. To take a comparison from artificial selection, or breeding: improved breeds of cattle, sheep, and other animals, and better varieties of plants take the place of the older and inferior kinds. In Yorkshire the ancient black cattle were supplanted by longhorns, and, says a writer, " these, again, were swept away by shorthorns as if by a murderous pestilence." "When we reflect on this struggle," says Darwin, " we may console ourselves with the full belief, that the war of nature is not incessant, that no fear is felt, that death is generally prompt, and that the vigorous, the healthy, and the happy survive and multiply."

Again, we find adaptations of structure as the result of use or disuse. The domestic duck has a bigger leg bone and a smaller wing bone than the wild duck, because it walks more and flies less The eyes of moles and other burrowing animals are rudimentary in size and sometimes quite covered with skin and fur. Animals inhabiting the depths of caves, such as the Mammoth Cave in Kentucky, are often blind, or even devoid of eyes. Those living near the mouth of the cave have sight suited to a twilight existence. There is no doubt that they are descended from ancestors having normal vision and losing it as successive generations penetrated deeper and deeper into the cave. In such cases blindness is often compensated by an improvement in the organs of feeling, such as antennæ. "It may be metaphorically said that natural selection is daily and hourly scrutinizing, throughout the world, the slightest variations; rejecting those that are bad, preserving and adding up all that are good; silently and insensibly working, *whenever and wherever opportunity offers*, at the improvement of each organic being in relation to its organic and inorganic conditions of life. We see nothing of these slow changes in progress, until the hand of Time has marked the lapse of ages, and then so imperfect is our view into long-past geological ages, that we see only that the forms of life are now different from what they formerly were." (*Origin of Species*, ch. iv.)

Thus Darwin enunciated the doctrine of evolution with regard to the organic life of the world. The lines of investigation that he followed and the conclusions he reached have been stated at some length, because it may truly be said that he established a new mode of thinking about the universe, though it is quite possible that he attributed too much to natural selection in the production of new forms, and too little to the experimental tendency which life appears to possess. At any rate, life proceeds by evolution, and this is equally true as regards the inorganic world. Nor do we believe that evolution is confined to our planet, the earth. We believe that it prevails throughout the universe, and that the stars and the other planets are in evolution likewise.

CHAPTER VI

THE EVOLUTION OF PLANTS

THE plants which clothe the surface of the earth at the present time form one stage in the whole evolution of plant life. That life, like everything else in the universe will continue subject to change, and what the next phase will be we cannot foresee. We can, however, discover something about plant evolution in the past.

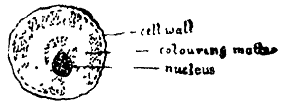
We know that our cultivated plants are descended from wild ones, and that their differences are due to the choice by man of the conditions under which they exist, and of the individuals from which new plants are raised. It is reasonable, then, to infer that our wild plants have also evolved from older types which have gradually been modified, mainly as a result of natural selection and change of environment. We can get direct evidence as to this from ancient plants themselves, embedded as fossils in the rocks. The record is not complete; it is less so even than that of animals; but where a plant has been fossilized its cell structure has often been preserved with wonderful completeness. We can also study the different types of plants that exist to-day—the single-celled plants, such as protococcus, the seaweeds, the lichens, and ferns, the cone-bearing trees, and the flowering plants which are at present the dominant family of the vegetable kingdom. We shall find that these represent what we believe to have been the main stages of plant evolution; and if we can discover links or possible lines of connexion between these very unlike types we shall have indirect but fairly reliable evidence of the descent and relationship of plants in the past.

The result of much study both of fossil and existing plants during recent years is that there no longer appear to be impassable gulfs set between the great families that dominated the plant world at different epochs; much, however, remains to be done before the exact relationships between them and between the smaller plant groups can be looked upon as established beyond a doubt. For example, the apparently sudden appearance of flowering plants during the formation of the chalk rocks is a mystery which the study of evolution has not yet solved. The development of plant and animal life is undoubtedly closely related, and just before the flowering plants the higher insects, bees, wasps, moths, and butterflies had appeared. These two facts probably have a bearing upon one another, and in this as in other cases we must not expect to find in change of environment alone an explanation of the differences which exist between the great plant families of different eras. The rocks of the coal measures, for instance, were being laid down at a time when the climate and other physical conditions of the earth must have been very much what they are in some parts to-day. Yet the coal measures, rich as they are in fossil plants, contain not a single fossil of the flowering plants that appear later in the chalk rocks. Quite apart from the influence of environment there appears to be in nature a tendency to produce spontaneously new developments in the individuals of a species—what in cultivated plants gardeners term 'sports'—and these new lines of development may have the most vital influence on the species. For if they benefit the individual showing them, that individual and its descendants, if they inherit them, will have a better chance in the struggle for existence, and the other members of the species will be at a disadvantage. In such developments environment has perhaps no more influence, says Darwin, " than the nature of the spark, by which a mass of combustible matter is ignited, has in determining the nature of the flames."

Again, evolution must not be thought of as invariably a progression from a lower to a higher organism, from a simple to a more complex. It is true that in each division of the earth's history since life began the vegetable kingdom increases both in variety and perfection. Yet, however simple an organism, it will survive if it is perfectly adapted to its surroundings, and a complex organism sometimes simplifies itself if by doing so it attains this end. Thus some flowering plants which have taken to fresh water have simplified their structure to compete with native water plants, and have lost all likeness to flowering plants because flowers are not suited to water life. For this reason when we examine simple organisms we cannot always be certain whether they represent a survival of a primitive type through perfect adaptation or a degeneration of a higher form, and this doubt exists concerning bacteria, the very simplest organisms, since they consist of a tiny single cell, possibly not even possessing a nucleus.

Still, since perfect adaptation ensures survival, there is no reason to doubt that some of the simplest plant organisms of to-day may be the living representatives of some of the first plants evolved from the cell that was neither animal nor plant by the formation of the green colouring matter called chlorophyll. As has been stated in an earlier chapter, life was first born probably on the warm, muddy shores of primeval lakes and seas, and here too and on the waters themselves would lie and float the green cells that were the first plants.

Protococcus, our simplest living plant, is a water-dweller still. It consists of a single cell containing protoplasm, a nucleus, and a green colouring body. It reproduces itself by dividing into four parts, similar in structure to the original cell, which remain within the wall for a time before they start an independent existence of their own. Simple as such an organism is, it is capable of development, and the ancestors of the highest plants probably started in as lowly a way. If the four daughter-cells fail to complete their separation from the mother-cell, but surround themselves with walls and proceed to divide again, we have the beginning of a cellular structure. This may become more and more complex by the modification of cells for the performance of work important to the plant as a whole, and by their building up into various tissues. In this way the higher plants must have evolved.



PROTOCOCCUS

As has been mentioned, the record of their evolution contained in the rocks is very imperfect. It is true that we have fossil plants millions of years old, the structure of which has been so perfectly preserved that it can be studied under the microscope in almost as much detail as that of a freshly gathered specimen. But of the plants that flourished during vast stretches of time after the appearance of the first green cells we know practically nothing We should not expect the soft tissues of the earliest plants to survive. Even if they had done so it is probable that the beds of rocks in which they were buried would have been destroyed in the course of the ages that have lapsed since they were laid down. Our earliest plant fossils, however, belong to the class of water plants, or algæ, one of the two primitive groups—the other being the land group of fungi (mushrooms, toadstools, etc.)—which have no distinctive structure for stem and leaf, the whole body of the plant being a mass of simple cells, and it is probable that these formed the only vegetable life on the earth for more than half the period between the appearance of the first living cells and the present time—a vast period comprising probably many millions of years. Nearly all the animal remains of this immeasurable space of time belong to animals that also lived in water, and it seems likely that for the greater part of the time organisms adapted to a life on land did not yet exist.

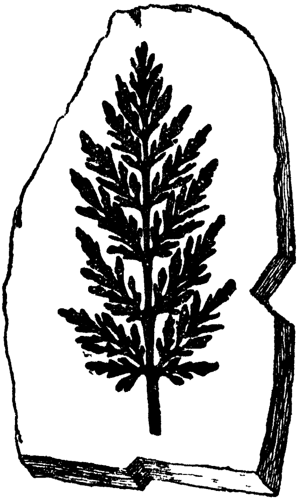
The algæ, then, formed the beginning of vegetable life, and contained the original forms of all other plants, and in the water plants of to-day, both fresh and salt, we can study the representatives of the ancestors of the whole vegetable kingdom. The algæ differ very much both in size and in variety of form. There are the minute fresh-water algæ which form the green covering of ponds and ditches, and there are gigantic sea algæ which can reach a length of 400 feet. In the Sargasso Sea of the Atlantic Ocean there are algæ forests that cover a space of about 40,000 square miles, and in the primeval ocean there were probably still larger forests that in the opinion of some geologists helped to form our coal seams.

The fungi are closely allied to the simplest algæ. They differ from most other plants in forming no green colouring matter, or chlorophyll, and in living, like animals, on organic food. They probably arose from the algæ as a result of adaptation to a parasitical form of life.

The lichens which form crust-like coverings on rocks, stones, trunks of trees, etc., are each of them composed of two distinct plants, an alga which produces chlorophyll and builds food material, and a fungus which lives upon it as a parasite. The two plants are so completely interwoven that the lichen appears to be a single organism.

The first stemmed plants were mosses and ferns, the mosses probably forming the transition stage between unstemmed plants and ferns. These formed the predominant vegetation during the period when the coal-bearing rocks were being laid down, but a few early cone-bearing trees were also in existence, these being the earliest plants to produce seeds. They must have arisen from the ferns, and they, with their simple and insignificant flowers, producing naked seeds, were the ancestors of the highest family of the vegetable kingdom, the true flowering plants, with enclosed seeds.

With the exception of the ancient seaweeds that have been mentioned, the fossil history of plants opens when they were already very highly organized, and as various in character as the plants of to-day, though they were of a more primitive type. They must have had an immensely long history behind them, which, as far as direct evidence goes, is a sealed book. This unrecorded history covers undefined but immense epochs during which plants evolved from their one-celled stage and became great and complex organisms. Many groups of animals came into existence, reached their highest development. and became extinct, as we know from the fossil record of the rocks, and still we know very little of plants. It is not till we come to that period of the earth's history when the carboniferous rocks were formed that we have much information preserved for us, but in them we have a wonderful record of the plants living when they were laid down. Besides many other beds, they include the coal measures, which are the buried remains of vast swampy forests. These alone reach sometimes a thickness of two miles and must have taken millions of years to form.



Fossil Fern

From "Secrets of the Hills' Craig *(Harrap)*

Each seam represents the entire existence of a great forest, the trees of which, generation after generation, lived, died, and decayed into vegetable mould, upon which another generation sprang up, until their *débris* had reached a depth of many feet. Then the plain on which the forest grew began slowly to sink. It became a marsh, and finally the sea rolled over the fallen trees; sand and mud, washed from the higher land by rivers, slowly buried them on the sea-floor, and the shells and skeletons of innumerable generations of ocean life increased the deposits which were making the shallow sea continually shallower. At last it was filled up. Its waters receded, and upon the mud brought down by the rivers a new forest flourished, until it too sank beneath the sea and was buried in mud, sand, and sea-animals' remains. A hundred distinct seams and the rock layers between them sometimes demonstrate the existence of a hundred different forests on the same site, each in turn overwhelmed by the sea. The immense weight of overlying beds converts the vegetable *débris* into the structureless, hard, shiny, carbonaceous material we call coal, but in spite of the great change which the plants have in general undergone, the coal measures have also preserved so much which has kept its form at least, or both form and structure, that we have a remarkable knowledge of the plants that existed during the period of their formation. Of the plants of later eras we have much less complete information, until we come to those of the present day.

There are two different types of fossils, produced respectively by incrustation and petrifaction.

In incrustation a plant or portion of a plant is encased in mineral material, which may thus provide a perfect print or cast of its surface. The tissues either decay or are changed by pressure into structureless coal. In the case of a seam of coal a whole forest in all its generations has been encased in mineral material. The mass of decayed vegetation has lost its structure, but the plants on the upper and lower surfaces of the mass have left their imprint on the hardened mud with which they are in contact. Thus we get the beautiful impressions of fern-like fronds with which most people are familiar.

In petrifaction the whole substance of the plant has been impregnated with mineral matter in solution. As a result of evaporation the mineral matter solidifies in the tissues of the plant, the structure of which in this way is often marvellously preserved.

In the English coal measures the most important examples of petrifaction are contained in the so-called coal balls, which are frequently found both in the actual seams and in the beds between in certain mining districts, especially in Lancashire and Yorkshire. These balls consist of vegetable remains of all kinds impregnated with lime, to which they owe the preservation of their minute structure, and embedded in mineral matter of the same kind, so that they resemble masses of stone. They were formed during the periods when the successive forests had sunk beneath the sea, and the lime which has gone to their formation is due mainly to the shells of the sea creatures that lived and died in the waters by which the forest was submerged. With the help of the fossils preserved in such abundance and perfection we are able to reconstruct the forest plants that flourished in the epoch when the carboniferous rocks were formed. It should be remembered that it is the swamp flora only of which we thus acquire a knowledge; we know nothing of the plants of that era which grew on high ground.

Coal Ball

From "Secrets of the Hills'
Craig (Harrap)

Still, even in those immensely remote ages—and the little we know of the plants of still earlier epochs shows them to have been in the main not very different—nearly as many different types existed as at the present day. All except the very highest groups were represented, but the aspect of the primeval forest in which they grew must have been strangely different from that of the forests growing now under similar conditions of position and climate. It was not in size that the plants differed—though some that were forest giants then have but puny and dwarfed descendants now. There were great and small then as now, but the average bulk and stature does not seem to have changed much through the ages. In that ancient forest where lizard-like reptiles crawled and dragon-flies darted about on a two-feet spread of wing—where no bee or wasp, no moth or butterfly, no bird or mammal, was ever seen, for they had not yet been evolved—in this forest there was not a single flower-bearing plant of the highest type. All that complex device for securing reproduction by means of seeds—that elaborate structure of infinite variety which we call a flower—had still to come into existence. The ruling family of that forest. trees a hundred feet high, were ancestors of the club-mosses that are now small herbs creeping along the ground. There were horsetails too, mostly great shrubs and trees, whose descendants, like those of the club-mosses, have shrunk greatly in size, ferns of many kinds, both great and small, fern-like plants bearing not spores but seeds on their fronds, cone-bearing trees of a type now extinct, and several other plants which have no descendants among living ones This was the vegetation the fossil remains of which we find in the carboniferous rocks, and which, compressed to the hardness of stone and with its structure lost, composes our coal seams; and many millions of years ago as the carboniferous rocks were formed, we find even in that remote epoch a highly organized vegetable life.

In the beginning of the era which saw the evolution of flowering plants the most striking family is that of the cycads fern-like, seed-bearing, but flowerless plants, represented at the present day by a very limited group. The great club-mosses and horsetails have been succeeded by smaller individuals of the same families, and none of the higher flowering plants have yet appeared. The rocks of this era are less rich in fossils, but trunks of cycads are sometimes dug up by the Portland quarrymen, who call them 'fossil crows' nests,' a name suggested by the short trunk hollowed at the top through the decay of the growing tip. One of these specimens, now in the geological department of the British Museum, is nearly four feet in height and three and a half feet in girth, but the trunk is usually much shorter.

In the latter part of the era the chalk rocks were being formed, and in them the fossils show that flowering plants have suddenly taken an important position. The lines of their evolution have not yet been clearly established, but a connexion is probable between them and the fern-cycad groups, and just before them the higher insects, bees, wasps, moths, and butterflies have appeared, a fact which probably has a direct bearing on their evolution. So much the most highly organized are they in the vegetable kingdom, and destined to take so dominant a place, that their arrival marks almost as critical a stage in the evolution of the plants as the appearance of man in the animal kingdom. The other plant groups shrink suddenly in importance. Cone-bearing trees are still present, but the species are far fewer than those of flowering plants, and the cycad representatives have become scarce.

In the era immediately preceding that of the present day—that in which most of the existing mountain chains of Europe were built—a flora is found resembling the plants now living, and flowering plants have assumed a predominating importance. At the present time they cover the face of the earth, adapting themselves to every climate, and finding a foothold in every position where plant life is possible. Of the other groups of plants only conifers hold their ground against them as forest trees in the higher latitudes of the Northern Hemisphere, and bracken and bog-moss cover considerable areas by reason of perfect adaptation to environment.

What is a flower—the evolution of which in a certain group of plants gave them the supremacy in the vegetable kingdom? It is a group of organs of reproduction, adapted for the securing of fertile seeds by means of animal and especially insect visitors, and it was in all probability the appearance of the higher insects on which its evolution depended. The lower classes of plants have neither flowers nor seeds; they are reproduced by spores. Such plants are ferns, club-mosses, horsetails, mosses, lichens, fungi, seaweeds, and most fresh-water plants The higher plants are reproduced by seeds, but the cone-bearing trees (pines, firs, cedars, and larches) and cycads have no flowers, but naked seeds, while the higher flowering plants have a closed casket, formed of one or more specialized leaves, called the ovary, containing ovules, which are the future seeds. The ovules will be fertilized when the pollen formed on specialized leaves called stamens enters them. As the ovary is closed the pollen cannot get at the ovules directly as it does in conifers and cycads. It is received on a sticky surface called the stigma, sometimes erected on a long stalk called the style. The whole structure, ovary, style, and stigma, is called the pistil. Each grain of pollen dust must send out a tube long enough to reach down the style into the ovary until its tip can enter an ovule, which is then fertilized and becomes a seed. It is by the perfection of their arrangements for securing the fertilization of the ovules and the success of their devices for securing the dispersal of fertile seeds that the flowering plants have triumphed over all the other families of the plant world.

CHAPTER VII

PLANTS AND THEIR ENVIRONMENT

IN spite of much that is still unverified in the history of the plants, we recognize four distinct eras in their development, though these no doubt merged into one another by imperceptible stages :

1. The era of water plants, both fresh and salt.
2. The era of spore-bearing plants, such as ferns, club-mosses, horsetails, and primitive seed plants.
3. The era of cone-bearing trees, such as pines, firs, cedars, and larches.
4. The era of flowering plants.

As the higher families of plants evolved the lower groups were supplanted by them, and either ceased presently to exist, or, if they did survive, suffered a continual reduction in individual size and in numbers, and were driven to the more barren localities and those to which their structure happened to be specially adapted. Thus representatives of all the four eras exist at the present day, but the highly organized flowering plants outrank all the rest in number and importance because of their greater power of securing survival by adapting themselves to environment. Indeed, if instinct is defined as unreflecting action for a definite object, then it may be said that plants have instinct no less than animals, and since the protoplasm on which life depends is the same in both, animals without nerves and plants experience sensation to the same degree. The infant stem does not mistake itself for the infant root and turn downward from the seed into the soil instead of upward into the air, and the mainspring of its action may quite fitly be called instinct, just as instinct guides the pollen tube to the exact spot of an ovule where it can gain entrance, and directs the plant in an infinity of ways to make the best of its environment. It is with a few of the countless ways in which plants secure a foothold on the earth, their share of food and light, and the fertilization and safe dispersal of their seeds that this chapter will deal. Even where plants are worsted by those better organized than themselves in the competition for these essentials, and die out, or are pushed into the background of the plant world, it will be found that they do important work in preparing the earth for higher forms of life.

This is the case with bacteria, those extremely minute forms of life that we usually associate with disease. They cause the decay of dead organisms, and so release the carbon and nitrogen stored in their tissues, which would otherwise remain uselessly locked up in them. During the early part of the process of decomposition offensive compounds are formed and evolved, but in the end nothing of the decomposed organism is left behind in the earth or the water but harmless nitric acid and a small quantity of mineral salts. The work of bacteria in providing the nitrogen, which is an essential plant food, in a form in which it can be absorbed in solution by the roots has been mentioned before.

All land plants, moreover, whether primitive or highly organized, aid in producing that loose and crumbled surface of the earth's crust which we call soil

—not only by penetrating the rock decayed by wind and weather in all directions with their roots, but by arresting dust carried by the wind and mud carried by water, and by adding fertilizing vegetable mould to the rock material. The first vegetation to cover the bare rock is made up of lichens (first the alga, then, when decay has taken place, the fungus, forming the lichen), tiny mosses, and water plants. On the layer composed of the dust collected by them and of their own dead stems and leaves larger plants of the same kind spring up and increase the depth of soil. Grasses and small herbs gain a footing next. Generation after generation rises upon the same site and lies there in decay, and in the end a forest may grow upon the deep soil that innumerable successions of plant life have formed.

There is very little of the earth's surface where plants cannot by adaptation secure a footing and gain a living. They contrive to exist amid perpetual snow and in rainless deserts. They secure their share of the light, without which, as a rule, they cannot live, by climbing upon the trees and shrubs that threaten to shut it out. A little dust or vegetable mould collected in rock crevices, the crannies of walls, fissures in the bark of old trees, and forks of branches is all that some plants require in order to thrive. In such positions we find in England moss, lichens, small ferns, and fungi; in the tropics the lower parts of tree trunks are sometimes covered thickly with ferns and brilliant orchids. It is on living or dead organic matter that we shall always find fungi, such as moulds, puff-ball, and mushrooms, springing up, and there are a few of the much more highly organized flowering plants which imitate them in this.

Water, containing various salts in solution, is an essential part of the food of plants. It is taken in by the roots, and an examination of the shape and placing of leaves shows how these are contrived to catch the rain that falls on the plant and conduct it by the veins and midribs to the ground just where the roots are situated. Usually the area covered by the roots is equal to the spread of the branches, and the leaves then slope downward and outward. Where the plant has a bulb, or a large main root with short rootlets, the leaf surfaces slope inward toward the central axis. Every one is familiar with the trumpet-like shape into which young lily of the valley leaves are coiled. They catch the rain as it were in an open cup and carry it in a narrowing spiral to the roots. Every plant by some device, simple or complicated, endeavours to secure its share of the water on which its life depends.

Most plants build up living material from inorganic compounds obtained from the air and the soil. Some, however, as fungi, ferns, and orchids, which flourish in damp, shady woods, obtain most of their food from decayed living matter in the shape of fallen leaves, pine-needles, twigs, and dead roots. On this vegetable mould we may find a growth of moss, fungi springing from the moss, smaller fungi thriving on the decay of the larger fungi, and bacteria finally resolving all the dead organic material into the same inorganic compounds that were taken from the air and the soil and used to build the tissues of the trees of the wood. Some plants, as mistletoe and many tropical orchids, not only use others as a support, but get their food, or part of it, not from dead, but from living organic material by sending their roots into the tissues of their host, and some have actually reversed the usual position between plants and animals, and feed on animals instead of animals feeding on them.

These last are the plants that have provided themselves with traps to ensnare small animals, especially insects. Some five hundred of these are known, and they have various types of pitfall for their insect visitors—allurements of nectar and bright colour, together with chambers which allow the insect to enter but not to escape, or gummy surfaces on which it sticks, while an acid fluid is poured out and digests it. Such are the bladderworts, water plants found chiefly on moors and bogs, which catch and devour small water animals, the larvæ of gnats and other insects, and little worms; butterworts, fly-catchers, pitcher-plants, which convert their leaves into traps; and sundews, which capture midges, beetles, small butterflies, ants, and even dragonflies.

PITCHER-PLANT

Of the first importance in a plant's life is the need to find a foothold on the earth and obtain a due share of light and food. Next comes the obligation to reproduce itself and so continue its species. Spores were the first means of reproduction in organized plants. Then fern-like plants were evolved which bore seeds instead of spores. Next higher in the scale came the conifers with their unenclosed seeds, and finally the true flowering plants, having their seeds contained in a closed ovary. The lower the plant in organization the more wasteful as a rule is the method of reproduction. Out of a million fern spores one perhaps may result in the development of a new plant. Even the lower groups of flowering plants show an uneconomical over-production of seed to counterbalance an inevitable waste It is the plants which have known best how to avail themselves of the services of insects in securing fertile seeds, and which have perfected the best devices for ensuring the dispersal of those seeds, that have been able to economize effort by producing comparatively few, and that have made their place most secure in the plant kingdom.

It is probable that the very earliest flowers consisted of the essential organs only—the stamens, a ring of specialized leaves bearing pollen, and the pistil—one or more specialized leaves containing the ovules or future seeds. To fertilize the ovules the pollen must reach the sticky portion of the pistil called the stigma, and the wind would help in this by often carrying the ripe pollen dust just where it was wanted. Still, a great deal would have to be produced, for much would be wasted, and the flower would remain nconspicuous, like those of grasses and sedges, for colour, scent, and nectar would be wasted on the wind.

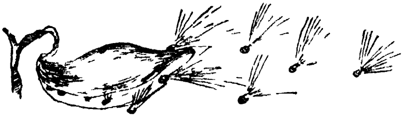
However, with the evolution of the higher insects matters were changed, for they could give much more efficient help than the wind in the fertilization of seed. An insect visiting the flower when the stamens were ripe would be sure to brush off some of the dust with its body and leave some grains adhering to the stigma. The problem for the flower was how to attract the insect. If this end was secured less pollen need be produced, for less would be squandered, and the flower consequently began its self-adaptation to insect help by flattening out an outer ring of stamens, which supplied a resting-place and attracted attention by their hue. Yellow petals were probably the first allurement offered by plant to insect. There followed, in the struggle to obtain the services of insects, perfume and the secretion of sweet juices, and the modification of cells needed to produce these seems to have been accompanied sometimes by a change of colour in the petals, so that white flowers mark a somewhat higher stage in evolution than yellow ones.

Bean Flower and young Beans

From "Stories of Plant Life," Bass (Heath)

However, small insects might visit a flower and feed on its juices without performing the services which these were intended to repay, and to keep out these undesirables some flowers barred the way to their nectar by a growth of hairs too dense for them to penetrate, or joined their petals into a long tube, at the bottom of which the nectar was concealed, obtainable only by a long-nosed insect such as a bee or a butterfly. More and more elaborate became the flower structure intended to preserve the sweet juices for the aristocracy of the insect world and at the same time to render it impossible for them to take them without rendering the services for which they had been lured to come. The pea or bean flower, snapdragon, and monkshood are instances of flowers perfectly adapted to this end.

Changes of colour continued to accompany the perfecting of fertilization devices, and red, purple, and blue denote an ascending scale in the evolution of the flowering plants. Spots and lines of colour directing the insect to the nectar secretions—always placed so that it must do the desired work in taking them—also indicate that the flowers which have devised these short cuts to their ends are aristocrats of the plant world. Moreover, since it often happened that a bee or butterfly bearing pollen on its body from one flower left some of it on the stigma of another of the same species, all the members of which told him by their colour and markings that his visits in search of honey would not go unrewarded, and since the seeds produced by this cross-fertilization proved strongest and most likely to survive, most flowers as a further device to secure the continuance of their species arranged that their own pollen and the pistil should never be ripe at the same time, and trusted entirely to insects to carry out cross-fertilization with another flower.



METHOD OF DISTRIBUTION OF MILK WEED SEEDS

From "Stories of Plant Life." Bass (Heath)

Having procured fertile seed, it remains for the parent plant to give them a satisfactory start in the world. They must if possible be prevented from merely dropping to the ground beneath, for in that case, stinted as they would be of air and light, they would have little chance of survival. To achieve their dispersal there are as many and as varied devices as those for bringing about fertilization. To assist transit by the wind many seeds are provided with inflated envelopes, or wings, or parachutes When the seed reaches the ground the wings or parachutes either fall off, so that the seed shall not be carried on again, or if they remain fixed they do useful work by anchoring the seed to the ground so that it has a chance of germinating. When fruit-eating animals appeared, succulent cases for the seed, as in the gooseberry and cherry, bribed the animal to carry it away. Some fruits, such as nuts, try to escape attention by being green on the tree and turning brown when on the ground. The edible part in this case is the seed itself, and the problem for the plant is to thicken the shell so that it may resist the sharp teeth of squirrels and other nut-eating animals, and to disguise it so that it may escape notice Other fruits and seeds are furnished with hooks by which they attach themselves to the feathers or rough coats of any bird or other animal that comes into contact with them. The animal usually carries them to some distance before it rids itself of them by rubbing.

An edible fruit is a reward offered to an animal for the dispersal of seeds Edible seeds, however, such as coco-nuts, walnuts, acorns, peas, wheat, rice, barley, and many others, contain stores of food intended not for animals, but to give the young plant a start in life. The same is true of edible roots, potatoes, parsnips, and so on. Here, as in general, animals consume the food stores laid up by plants for their own use.

Plant life, it will be seen, is both subject to thinning by the attacks of animals and assisted by animals to multiply. When animal life evolved (destined as it was to obtain its food from plants) it must have seemed that plant life must perish before this new host of enemies. On the contrary, though the struggle for existence was made keener, the evolution of plants was assisted by this radical change in conditions. As has been seen, in the fertilization and dispersal of seeds animals could afford most valuable help. When, however, the plant had not immense powers of multiplying it was necessary to develop some protection for the green parts, without which plants cannot live, against the attacks of animals, who are often driven by hunger to seek food even at the cost of destroying their own means of subsistence. It is only man who protects the plants to conserve his future food stores. With this end in view some plants developed spines and prickles upon those parts within reach of grazing animals ; trees produced a tough bark ; shrubs, such as rhododendrons, indigestible tissues. The stinging nettle evolved a defence, and some sense told the animals that hemlock, henbane, monkshood, and many other plants were poisonous to eat.

In these and similar ways the plants held their ground, and, even in situations exceptionally favourable to them, as in tropical forests, were able to put animal life at a great disadvantage. On the whole, plant and animal life progressed side by side, animal life dependent on plant life and preying upon it, yet at the same time rendering it services which enabled the plants to hold their own.

CHAPTER VIII

EVOLUTION OF ANIMAL LIFE—THE LOWER FORMS

ANIMAL life, like plant life, began on water, and advanced from simple forms to forms more highly organized. We cannot, as has been said in the case of plants, expect to find a perfect record of their evolution in the rocks. Some animals had no structure that could survive in fossil form; others left their bones in rock unsuitable for their preservation; the rocks themselves in many instances have been unmade and remade time after time. As Darwin says: "We must look at the geological record as a history of the world imperfectly kept." We have, however, certain fossil series showing the development, and sometimes the disappearance, of animal types; we have a wonderful number of types preserved; and we have evidence in the age of the rocks in which their remains are preserved that higher and higher groups of animals appear in successive periods of the earth's history. Backboneless animals make their appearance before backboned. Backbones are developed first in fish. Two geological epochs later—by which vast stretches of time must be understood—we find the first amphibians—that is, animals successively at home both in water and on land; and this is momentous, since it marks the fact that animals destined for a life in water have succeeded by adaptation of structure in accommodating themselves to life on dry land. Two elements are now subject to the animal kingdom. It is the rocks of the carboniferous epoch, the coal measures of which are the oldest rocks which have preserved for us an abundance of plant fossils, which furnish us with the fossil remains of the first amphibians Reptiles appear in the next epoch, in the next but one birds, the first warm-blooded creatures—and we possess a fossil showing the actual transition between reptile and bird—and with the conquest of a third element, of which only insects had been free before, water, earth, and air all lie open to the higher forms of animal life. Lastly come the mammals, also a warm-blooded group, whose evolution will culminate in the arrival of man.

The history of the life of the earth can be divided into five main periods according to the animal and vegetable groups that predominated in them.

The first and longest division, more than half the whole immeasurable length of time that has elapsed between the first appearance of life on the earth and the present day, may becalled the epoch of water plants and backboned animals without skulls; the second, that of ferns and fishes; the third, that of cone-bearing trees, and reptiles; the fourth, that of the higher flowering plants, and mammals; the fifth, that of cultivated plants, and man.

During the epoch of the water plants all the animals lived in water too—the backboneless animals that preceded the backboned and the backboned animals without skulls out of which the fishes developed.

The epoch when ferns, club-mosses, and horsetails predominated in the plant world includes the period when the coal measures were laid down. In these are found the remains of the most ancient land animals, including spiders, insects, amphibians, and reptiles, but these animals must have been few compared with the immense numbers of primeval fish.

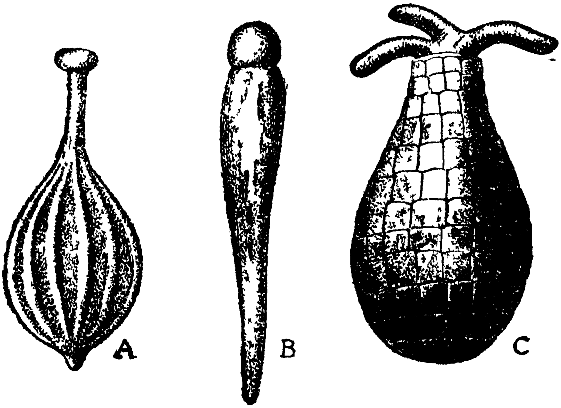
The epoch of the cone-bearing trees extends to the end of the chalk formation. During this period the first birds and mammals appeared, but the dominant family in the animal world was the reptile, which included not only forms allied to the present-day crocodiles and lizards, but gigantic flying lizards and land and sea dragons.

Flowering plants with enclosed seeds, and mammals had already made their appearance in the third epoch, but it was not till the fourth that they attained their complete supremacy.

The fifth and last great epoch in the history of the life of the earth may be termed that of man, because he has exercised a greater influence upon plant and animal life than any other creature.

We have seen that our simplest living plants are unicellular, and that they may possibly be direct representatives of the earliest plants, which, though no fossils have survived to prove it, must have been just as simple. Our simplest living animals, the protozoa, as they are called, are also unicellular, and, though we cannot affirm that they were the first animals evolved, yet we find their remains in the rocks as far back as there is any record of life at all. Some of our living protozoa form skeletons, others do not. The latter could not be fossilized, but the remains of skeleton-forming protozoa are not only common in the rocks, but have had a large share in building them. Many sandstones and limestones, and especially the white chalk, are practically made up of the minute and very beautiful and varied shells of these creatures.

In the higher animals the body is made up of a vast number of cells built up into tissues, forming skin, nerve, muscle, or bone. The protozoa, consisting of one cell only, have no definite tissues In the former the cells are modified to perform some special service; in the latter the drop of protoplasm that forms the protozoon has to fulfil all its functions But this protoplasm, with its firmer speck, or nucleus, in the centre, has a very complicated structure and may assume very varied forms. Some protozoa have their outer surface hardened so that they retain a definite shape and can usually take in food only at one opening. These have no skeleton. The rest have no hard skin, and the protoplasm may change its form or extend into threads and be withdrawn again. These threads enable the animal to move, and they also catch up food, which is taken into the central mass at any point. Of these protozoa some construct no skeleton, while others have shells of



TYPES OF PROTOZOA (MUCH MAGNIFIED)

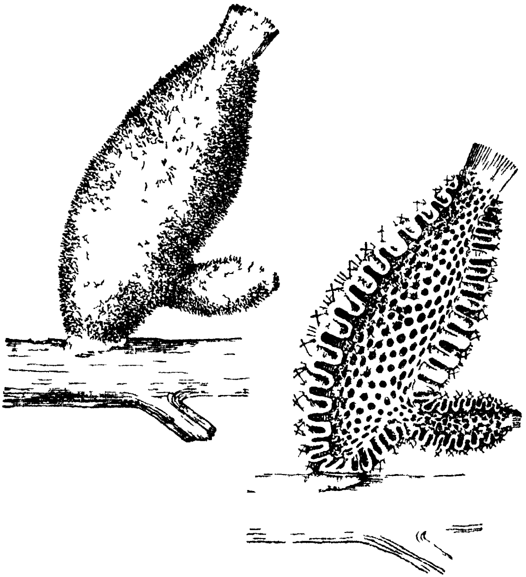
From "Zoology," Cockerell (Harrap)

a thousand different patterns which remain constant in each species.

Whether encased in a skin or free the protozoa multiply by division. The nucleus splits into two, which repeat the operation, and thus either organisms with several nuclei are formed or the nuclei break away and lead a separate existence. Their failure to do so, followed by each nucleus surrounding itself with a cell wall, in animals as in plants, is the beginning of a multicellular structure or true body. The unicellular protozoa, it has been said, possess a kind of immortality, since the existence of the parent-cell is merged in that of the daughter-cells. Division can go on indefinitely until the protoplasm at last appears to lose its reproductive energy. Fusion of two cells, however, renews it, and division continues as before.

Organisms with bodies — that is, multicellular animals—arise, then, from the subdivisions of a single cell. These daughter-cells, however, unlike the daughter-cells of unicellular animals, do not in general retain the characteristics of the parent-cell. In the higher animals they undergo modifications to form different tissues, which have different work to perform. The collection of cells that we call a body does not go on extending itself indefinitely by cell-multiplication. It reaches a definite size, has a definite shape, and passes through definite stages. It contains special cells which carry out the work of reproduction, which are quite distinct from the other body cells, and do not take any part in building up the body. Thus as soon as bodies began to be built a fresh method of starting new life was discovered, a method which left the parent organism with its individual life, but subject to death.

Among the groups of multicellular backboneless animals descended from the protozoa are sponges. These with the exception of one family all live in salt water. In some respects they closely resemble the protozoa, and they have no organs of sense or locomotion. Most of them are capable of being fossilized, and we have some very ancient specimens, a number of which represent extinct families.



A Simple Sponge attached to a Seaweed On the right the same Sponge in Vertical Section

From "Zoology," Cockerell (Harrap)

In the group which includes corals, sea-anemones, and jelly-fishes the body wall encloses a single hollow chamber—a sponge has many—which is the digestive cavity of the animal. Most of the members of this group, as is the case with sponges, are more or less the same all round; there is nothing that we can regard as a head, and their bodies have no right or left, but we find among them primitive sense organs. Many are soft-bodied animals which could leave no fossil traces except impressions they have made on a muddy shore, but coral fossils are not only found in great numbers, but actually form the substance of many rocks.

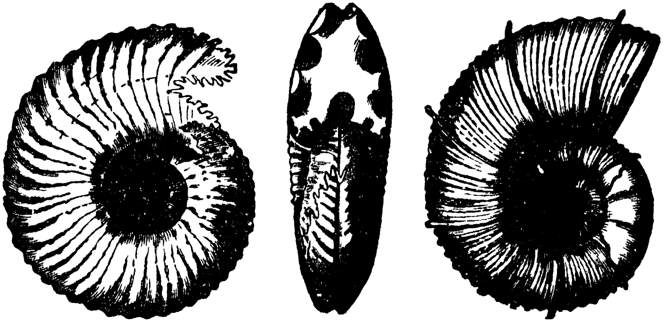
The remaining groups of the backboneless animals have all evolved nerves, blood-vessels, and a digestive system which is shut off from the main body cavity.

The sea-urchin, starfish, and sea-lily are living representatives of classes all of which have left fossils, and other ancient fossils represent related classes now extinct. They are important as rock-builders. These animals, though they mark a distinct advance in organization, are still the same all round. Nothing resembling a head has yet been evolved.

Sea-worms, earth-worms, water-worms, and leeches have segmented bodies and were probably the first animals which began habitually to move with one part of the body always in front—in other words, to acquire a head, and consequently a right and left. The head, being the portion with which new ground would be first explored, would have its nerve cells stimulated, says Professor J. A. Thomson, and thus the evolution of the brain might begin. Darwin found that worms showed distinct intelligence in their way of drawing leaves into their burrows by the narrow ends so as to have as little trouble as possible.

Insects, centipedes, lobsters, barnacles, spiders, scorpions, and many less familiar animals form the next great group.

They have a segmented body produced into hollow, usually jointed limbs. In the more primitive forms the whole body is divided into similar segments, and a pair of limbs is borne on each, but in later forms several segments are fused more or less completely, especially at the head end of the body. A more important development is that, though in structure all these limbs are organs of locomotion, some at the front end of the body round the mouth are used for seizing and biting food. Feet have become jaws. In water animals of this group some limbs behind the jaw limbs have developed plates which act as gills. The land animals breathe by means of lung sacs or tubes opening to the air. In fossil scorpions of the carboniferous age we see the conversion of gills into lungs as the animal emerged from the water. All existing scorpions are land dwellers. The development of eyes and feelers in animals of this group marks another stage in the evolution of the head. All the classes are represented by numerous fossils. Insects are the most highly organized animals of the group and are of great importance on account of their connexion with the evolution of the flowering plants.



AMMONITES

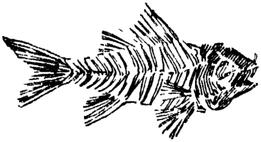
Molluscs, including oysters, snails, whelks, cockles, and cuttlefish, are among the more highly organized backboneless animals, having a distinct head, a mouth, digestive and nervous systems, blood-vessels, heart, and gills. Their soft bodies have no internal skeleton, but a hard shell is usually formed on a part of the outer surface, and these shells form the chief part of their fossil remains. The cuttlefish, squid, and octopus have long arms or tentacles round the mouth, strong jaws, power of locomotion — all modifications of structure which would enable them to prey on other animals—and conspicuous eyes, which are as highly developed as those of a backboned animal.

It has been noted as one of the main distinguishing marks between plant and animal life that animals in general are much more active than plants, the reason being that plants, obtaining their food from the air and the soil, have no need of locomotion to seek it, while this power is usually a necessity to animals, since they live either on plants or on other animals. Plants, however, have a limited power of movement, and this is all that is possessed by some of the lower backboneless animals. The simplest animal organisms of all, the protozoa, have some locomotive powers, but sponges, some star-fish, sea lilies, and corals for nearly their whole lives, do not actively change their position, or are even anchored to something, such as a shell, other corals, or the sea floor. Movement is confined to arms and to vibrating hair-like organs which collect food and regulate the process of breathing. The higher the organization of plants and animals, however, the less they resemble one another; and we find in animals that the progress in locomotion, which distinguishes them more from plants, is attended by development of the nervous and muscular systems and of the brain. Movement is easier on water than on land, where balance and weight assume a new importance, and we find the animals that have adapted themselves to dry land more highly organized than their brethren of the water. In the group that includes insects, centipedes, lobsters, and spiders the most highly organized animals are the flying insects, which have adapted themselves not only to land but to air. When we come to backboned animals we find that the great age of the reptiles was that in which they had representatives at home in air, on land, and in water, and we recognize at once that the highest animals—the birds and mammals—are those that display the greatest and most continuous activity.

CHAPTER IX

BACKBONED ANIMALS: FISHES, AMPHIBIANS, REPTILES, AND BIRDS

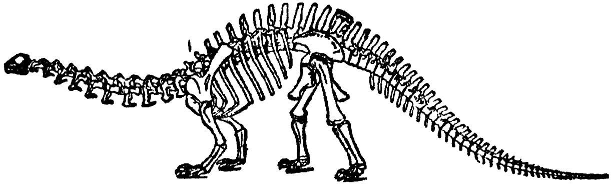
IN immeasurably ancient rocks, which have given us little but seaweeds to tell us of the plants that were living when they were laid down, appear the remains of the first backboned fish. There are immensely older rocks containing fossils, but among these no fossil fish of any description are to be found. We must not suppose on that account that none were in existence before the first evidence of them is found in the rocks. Before the strange fish forms which have left remains in the shape of teeth or scales or internal skeletons there were probably entirely soft-bodied fishes, which could leave no record of their lives for later ages to read. The earliest backboned fishes probably resembled the sharks and dog-fish of the present day ; they have left little but teeth and spines, but from these we know that in later epochs their descendants sometimes reached a huge size, probably as much as a hundred feet in length. With the exception of these ancient sharks few of the earliest fishes have present-day representatives. Fish with thin, flexible scales and symmetrical tails, such as carp, roach, salmon, and herring, as well as all flat fish, are of comparatively recent origin, making their appearance in the chalk rocks that saw the first flowering plants. The contemporaries of the ancient sharks were fishes with hard, bony scales, large bony plates on the head, and unequally divided tails. These scales are well preserved, and immense numbers of the bony head-plates of one of these fishes are found in rocks in the English Midlands and in Scotland. The bony-scaled fishes have few living descendants, but among them are the sturgeon, the bony pike which lives in the lakes of North America, and a curious fish which is found only in the Nile.



Fossil Fish

Later than the bony-scaled and shark-like fishes—some twelve million years at a rough reckoning may have lapsed between the first appearance of these two groups—we find in the rocks of the coal measures the first amphibians, ancestors of the newts, salamanders, frogs, and toads of to-day. There was an immense variety of them, some being as large as a large crocodile; they were the dominant animals of the coal forests, as later on the great reptiles and the mammals were successively supreme. By infinitely slow adaptations water animals, whose young remained fish-like in form and breathed by gills, became fitted for a swamp life. They acquired lungs, voice, and a movable tongue; the fishes' two pairs of fins became fore- and hind-legs, which, however, scarcely raised them from the ground; the webbed rays of the fins diminished to four or five, the ends of which remained free and formed fingers and toes.

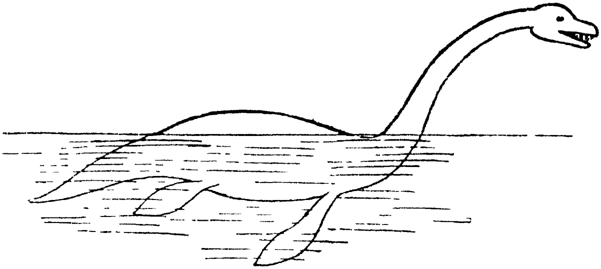
Two stocks evolved from the newt-like forms of the earliest amphibians — one represented by the frogs, toads, and salamanders of to-day, animals still spending their early life in the water where they arose, the other the great reptile stock which in its heyday occupied a position in the animal world comparable with that later on of the great mammals, the tigers, elephants, rhinoceroses, and giraffes. They reached their greatest development in the epoch immediately preceding that of the chalk rocks, and at their culminating point another group of animals destined to supplant them makes its appearance. One reptile stock had given rise to birds, the first warm-blooded animals; the other and more important warm-blooded group, the hairy-coated mammals. destined to attain such size, strength, and variety, appeared among the great reptiles as small, rat-like creatures with, we may imagine, no sign of their great future about them. Yet the great reptiles inexplicably died out and only the smaller forms have living representatives in the crocodiles, tortoises, snakes, and lizards of to-day.



SKELETON OF A DINOSAUR (BRONTOSAURUS)

There were herb-eating reptiles, and carnivorous reptiles which preyed upon their vegetarian brethren. They had completely mastered locomotion on land, and some of them had even made the conquest of the air. Though at one time they had completely abandoned a water life, some of them went back to the sea, and by their huge bulk assumed a position among its denizens like that of present-day whales and porpoises. In all three elements they were the dominant animals.

The oldest members of the group were the theromorphs, some of whose bones bear so close a resemblance to those of mammals that they have been thought the possible ancestors of this group. They carried their bodies clear of the ground and probably had very much the movements of a dog. A skeleton of one of these, found in Cape Colony, is in the Natural History Museum at South Kensington. It is herbivorous from its teeth, and stands eight feet high. Other varieties resembled the rhinoceros in their huge tusks, or had strange crests. One carnivorous theromorph found on the banks of the river Dwina has a skull two feet long and huge tiger-like teeth.



PROBABLE APPEARANCE OF PLESIOSAURUS SWIMMING ON THE SURFACE OF THE WATER

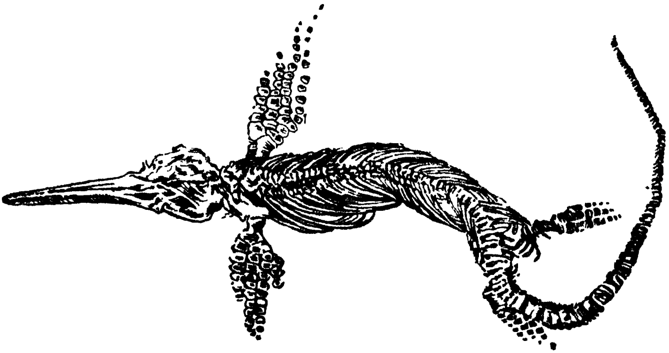
However, the group of extinct reptiles which corresponds most closely to the great mammals—elephants, rhinoceroses, kangaroos, etc.—were the dinosaurs. There was a carnivorous stock, the lions and tigers of their day, though they were not the ancestors of the true lions and tigers, which, as has been mentioned, possibly descended from the theromorphs, and a vegetarian stock which they hunted. Some of the dinosaurs, both carnivorous and herbivorous, resembled kangaroos in their habit of standing and partly running on their hind-legs only. Thus standing they could reach with their fore-legs shoots of trees twenty feet from the ground. The first skeleton of these kangaroo-like dinosaurs was dug up in Sussex. Twenty-two huge skeletons were afterward found entire in a coal mine near Brussels, and seven of them were set up in the Brussels museum. A cast of one of these is in the Natural History Museum. Bird-like varieties of these dinosaurs no bigger than a gull existed at the same time as the great forms.

Some great dinosaurs went on all fours One skeleton of this type dug up in Wyoming is eighty feet long. A good deal of its length is accounted for by a very long tail and a very long neck, bearing a head extremely small in comparison, but its body is as big as that of a big elephant and its back is fourteen feet from the ground. There were extraordinary crested dinosaurs, as there were theromorphs, and again there were some that were like three-horned rhinoceroses in size and appearance.

The reptiles which after ages of evolution into land forms went back to the sea were the plesiosaurs and ichthyosaurs. In these the fore- and hind-legs which had been evolved from fins became paddles, but retained the structure of legs. The plesiosaur, which measured about thirty feet from snout to tail, had a long, swan-like neck and a long head furnished with pointed teeth. It no doubt preyed upon fish and probably upon the birds and lizards of the shore. The plesiosaur was extinct ages before the evolution of man, or it might have given rise to those legends of the sea-serpent which have persisted to the present day.

The ichthyosaurus had a long head and short neck, and strongly resembled the porpoises and grampuses among living whales. All these water reptiles used their tail as the chief swimming organ.

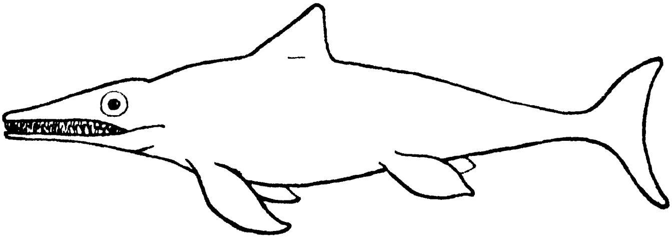
The flying reptiles—dragons of the air—were the pterodactyls, which varied in size from that of a robin to huge creatures with a twenty-foot spread of wing. Unlike birds, they had both fore- and hind-limbs clawed.



SKELETON OF ICHTHYOSAURUS PRESERVED IN LIASSIC ROCK

Their wings resembled those of a bat rather than those of a bird, since they were covered with a membrane instead of feathers. This membrane spread from one enormously elongated finger to the side of the body and the short hind-legs. From the great activity implied by flying it is probable that the pterodactyls had better lungs than are possessed by modern reptiles, whose torpid periods are due to changes of temperature combined with a breathing system far inferior to that of birds and mammals.

The remains of the great reptiles disappear from the rocks at the close of the chalk period. Why they died out we can only surmise. Modern reptiles are cold-blooded and if the great land and air reptiles remained cold-blooded when they left the sea and exposed themselves to the more varying temperatures of a life on land they would be at a great disadvantage when the warm-blooded birds and mammals appeared, not only clothed in non-conducting coats of feathers, blubber, and hair, but possessing an internal mechanism for maintaining at a constant temperature the heat produced by the oxidation of food material. The comparative immunity to change of temperature thus attained by birds and mammals would give them much greater activity than any cold-blooded creature could continuously display, and assure them of predominance in the animal kingdom. If, however, as is quite probable, the great reptiles had evolved some means of maintaining bodily heat, we must look for some other reason for their disappearance, and this was probably lack of brain. In many types the head is ridiculously small compared with the animal's great bulk—and bulk alone is a doubtful advantage, since it is conspicuous and needs a large amount of food for its support—and even where the head is large, as in the rhinoceros-like forms, the brain itself is tiny in proportion to the creature's size. Birds, and still more so mammals, are



PROBABLE APPEARANCE OF ICHTHYOSAURUS

immensely superior in brain to any of the earlier evolved types of animal life.

Birds, though certainly derived from a reptile stock, are not closely related to the pterodactyls. They are probably descended from the kangaroo-like group of dinosaurs which had fore-feet with five toes and hind-feet with only three. The fore-limbs may have become first swimming paddles, then organs used for beating the air and raising the body out of the water for a short flight, and lastly the feathered wings which modern birds possess.

A Long-tailed Pterodactyl

The fossil remains of birds are not very numerous. We have some from the chalk rocks, including birds with teeth like those of reptiles, and two remarkable fossils of the earliest known bird from the rocks of the preceding epoch. These skeletons were found in the lithographic stone of Bavaria, and the impression of the feathers is clearly shown on the hardened mud of which it is composed. The archæopteryx, as the bird has been called, was about the size of a pigeon and resembled existing birds in its skull, merrythought, and legs, and it had four toes. It had teeth in both jaws, a long tail like a lizard's made up of many vertebræ, and a wing which shows three distinct fingers, each ending in a claw. It resembles a lizard-like reptile more than any known bird, but that it was a true bird is proved by its legs and feathers, and no doubt it had a long line of predecessors in the evolution from the reptile stock.

In the more recent rock layers various remains are found, including a monstrous South American bird which stood twelve feet high and had a huge beak and claws. Great wingless birds resembling the African ostriches and Australian emus have left their skeletons in recent deposits in New Zealand, which still possesses a small wingless bird in the kiwi or apteryx. The dodo which the Portuguese and Dutch found in Mauritius rapidly became extinct because, having no dangerous enemies until the arrival of man, it had lost the power of flight. The great auk which, like the penguin, used its wings for swimming and not for flight, used to be common in the Shetland Isles, Iceland, and Greenland, but became extinct about seventy years ago. Birds which are either wingless or have ceased to use their wings for flight have lost the advantages bestowed on birds in general by their structure and warm blood—the activity which enables them to range the whole world in search of suitable environment. It is this very width of range which has given them, with mammals, a predominant place in the animal kingdom.

CHAPTER X

MAMMALS

IN the heyday of the great reptiles we begin to find traces of the highest group in the animal kingdom—the mammals, destined in the course of evolution to produce man. Sprung probably from an early reptile stock, they appeared at a time when the animal world was dominated by the great carnivorous species, and with these enemies in the field the feeble progenitors of the mammal group—in size no bigger than a rat or mouse—could escape extermination only by their insignificance and their ability, as shown by their teeth, to thrive on any kind of diet. Yet, tiny as were the forms of the first mammals, they displayed such improvements of structure as were bound, if only the group avoided early destruction, to ensure its triumph over all competitors. Whether it was due to the pressure of the mammals, or to some unexplained cause, the great reptiles died out in the epoch of the chalk rocks—the epoch when flowering plants attained predominance in the plant world—and the mammals, already of great variety and importance, succeeded to their supremacy.

These highest of the backboned animals surpassed the earlier evolved groups in efficiency of organization. They had more effective lungs and heart, better organs of the higher senses, and a more complex brain, which showed enormous development in the later types which were successful in their struggle for existence.

The head, as the seat of the intelligence and higher senses, is more conspicuously marked out from the neck and body in mammals than is the case in the lower backboned animals; the organs of scent and hearing are more complex, and in the case of ears marked out by flaps of skin movable by special muscles—a power lost by disuse in man in general, but persisting in a few individuals. Like birds, the mammals possessed the advantage over reptiles of warm blood, making them more independent of variations in temperature, and like the birds they had also non-conducting coats, not of feathers but of hair, a development shown by no group evolved before them, but characteristic of all

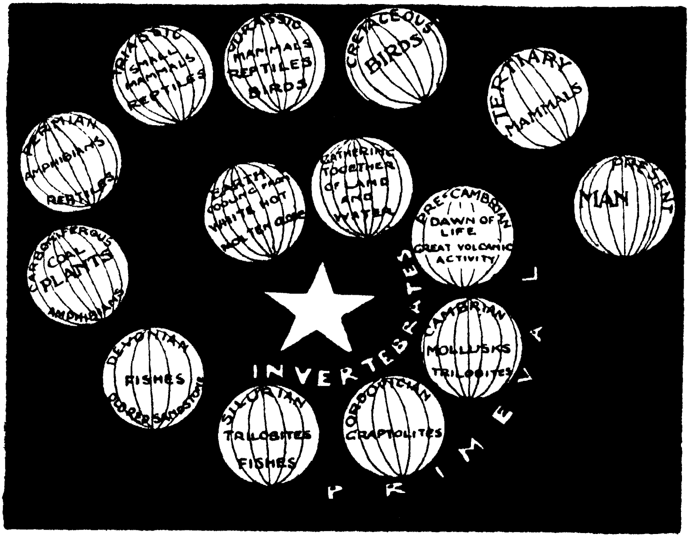
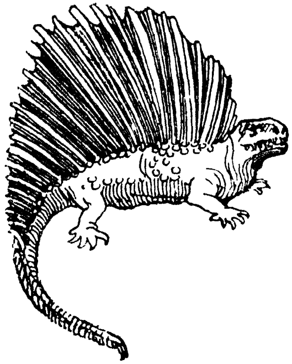


Chart of the various Stages in the Evolution of Life on the Earth

From "Secrets of the Hills," Craig (Harrap) mammals—though in the case of whales, whose non-conducting coats are of blubber, the hair is reduced to a few bristles on the lips. The advantages conferred by warm blood and superiority of brain are seen by the alertness and activity of mammals, who, in general, are not subject to the prolonged periods of stupor familiar in animals of lower organization. Increased powers of locomotion were given by elongation of the limbs, shortening of the tail, and development of muscles. Some mammals, as the present-day kangaroos, lemurs, monkeys, and apes, achieved a mode of progression by which the fore-limbs were more or less set free for grasping. In man, and man alone, the arms have been completely released from the support of the body, and so the craftsman's skill has become possible. Bats are the only true flyers in the group. 'Flying' squirrels do not really fly. When they jump from branch to branch they spread out a flat surface on each side of the body which, acting as a parachute, carries them through the air for some distance without falling. Whales have evolved another mode of locomotion, but are in all probability descended from land-dwelling ancestors. Their enormous bulk — they include the hugest creatures that ever existed, the eighty-five-feet-long rorquals, surpassing in size even the great reptile dinosaurs—would be evolved after they had adopted a water life, where weight would no longer have to be supported by muscle. Though high organization of structure is as a rule accompanied by large size, and the mammals are in general larger than the other backboned animals, a stage is reached fairly soon in land animals when further increase of bulk with its accompanying cumbrousness and conspicuousness is a drawback rather than an advantage. Thus we find that among mammals the water-dwellers are the largest, land animals come next, and last the tree-dwellers and 'flying' mammals, which, to maintain their equilibrium when moving, need enormous muscular power in proportion to bulk.

Thus, with powers of locomotion inferior only to those of birds, and like birds able to conserve an internal warmth which enables them to endure great variations of temperature, the mammals have spread over most of the earth's surface, from regions of Arctic cold to those of tropical heat. The number of existing mammal species is, however, less than that of either birds or reptiles ; it is less than it has been in earlier epochs, so that from the point of view of variety it may be said that the culminating point of the mammal group is past. As the beginning of this decline appears to coincide with the appearance of man it is at least probable that man contributed to it. At the present day his supremacy is such that he exercises a great controlling influence on the whole animal world. Because the usefulness of mammals to man is greater than that of the other animals their natural predominance is backed by their economic value. More and more in the future the 'fittest' may be chosen from a human standpoint, and man may supplant nature in selecting those species which he wishes to survive. It does not follow that the power of selection would be used wisely. Cruelty and greed have resulted, for instance, in the extinction of the king bird of paradise, the most beautiful of living things. Human interference with the design of nature might conceivably lead to the downfall of man.

The origin of the mammals, as has been mentioned, has been traced with considerable probability to the theromorph branch of the great reptiles. These show signs in all parts of their skeletons of evolution along mammal lines, and in the particular species from which mammals are believed to have been derived there is a marked resemblance to the higher group in the skull and teeth. Instead of sprawling like the typical reptile they carried their bodies clear of the ground on legs of fair length, the segments of which had the relative position characteristic of mammals. In general the size of the theromorphs appears to have been that of a wolf or a bear, so that the earliest mammals showed a degeneration in this respect from their ancestors, or, as is more probable, sprang from co-existing smaller types.

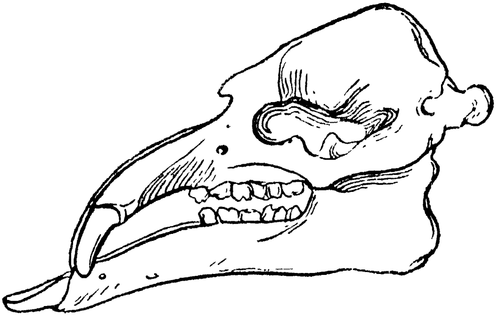

Probable Appearance of a Crested Theromorph

The oldest mammal remains known to us consist of teeth and very small lower jaw bones found embedded in firm-textured rock. These jaws are seldom as much as an inch in length, and appear to have belonged to small opossum-like creatures about the size of a rat. A few such remains were discovered about eighty years ago in the Stonesfield slates near Oxford. Mammals, though the latest evolved animal group, are shown by their fossil remains to be of exceedingly ancient origin, but the earliest types are all extinct, and it is not till the close of the chalk epoch and the opening of the present era of the earth's history that we have any evidence of the existence of the ancestors of the modern mammal species. Early in this epoch we find most of the existing orders, as well as some that have now disappeared The number of types goes on increasing to the middle of the epoch, when a gradual decline in variety sets in, and this diminution of species has continued to the present day, as instanced by the recent disappearance of the quagga, and the lessening numbers of the American bison and white rhinoceros. From the early stock of small mammals there appear to have been two offshoots, one showing a specialization of structure that left the brain undeveloped, and which consequently died out entirely—unless the pouched animals of Australia are its representatives, surviving because the fact that Australia was early cut off from communication with the rest of the world preserved them from the competition of animals with developing brains —the other branch giving rise to the species which exist to-day. It is believed that the ancestors of all the mammals were little tree-dwellers with small heads and long tails, living in swampy forests. Most of their descendants deserted the forests for the plains, and brain-growth was accompanied in them by changes in the body which resulted in such different types as horses, cattle, deer, camels, and lions. Others remained in their original homes, and little essential change took place in them except the all-important development of brain.

It is often supposed that the animals of to-day are puny descendants of giant predecessors. That is not so. As has been seen, the earliest mammals were all small, and a gradual increase in size seems to have taken place, in some cases producing huge forms in which bulk was disproportionate to brain, and which were doomed to extinction. A study of the descent of rhinoceroses, camels, horses, and other existing orders of mammals makes clear the fact that the types of to-day have gradually evolved, in increase of size as in other respects, from smaller ones of the past. The great extinct beasts are often found to be not the true ancestors of any living types, but representatives of related ones, which disappeared and left no direct descendants. When a group of animals meets with adverse conditions, such as the pressure of new enemies, or changes of climate and scarcity of food, it is the large types, which are conspicuous and also require much food, which tend to disappear, while the small forms escape notice, need little to sustain them, and have a better chance of survival. Thus the small tree-sloths, armadillos, and ant-eaters of South America are the present-day representatives of small, perhaps smaller, ancestors which were contemporary with the giant sloths and armadillos which are now extinct. The latter were dominant as long as South America was an island, cut off from the evolution of the great mammals in North America, Europe, Africa, and Asia. But when South America became joined to North America, and received from her the mastodons, horses, tapirs, tigers, and other animals that had been produced during her own insular existence, the great forms succumbed to the pressure of their better organized rivals for the possession of the land, while the small forms were able to carry on their race.

Present-day horses are bigger than extinct horses, and much bigger than their three- and four-toed ancestors. The first undoubted horse-like animal, found in the rocks of North America, is not more than eleven inches in height. Present-day elephants are as big as any of their predecessors, and much bigger than their early ancestors. The great reptiles, in spite of their eighty-foot length, were small in bulk compared with the biggest existing whales, the size of which has never been surpassed by any animal of any kind.

There are vast numbers of extinct mammals related to existing lions, bears, hyenas, horses, cattle, sheep, goats, antelopes, and other warm-blooded, hairy quadrupeds. There are many extinct mammals which have no direct representatives in these days. Among the latter the dinoceras, a strange creature the size of a rhinoceros, had three pairs of horns on the top of its head and a pair of huge tusks, produced by the enlargement of the upper canine teeth. Another great animal, known as the titanotherium, resembled a rhinoceros, but had a pair of horns placed side by side on the nose. Characteristic of these and other horned animals of great bulk now extinct is the small brain, the volume of which was far smaller than that of existing great mammals, though the skull in some cases is three feet in length.



Skull of Palæomastodon, a Remote Ancestor of the Elephant

The extinct great armadillo of South America, known as the glyptodon, like the little armadillo of the present day, carried armour formed by bones in the skin. The superiority of the small, surviving form is seen in an improvement which the great one never evolved. The armour is jointed, enabling the animal to roll up into a ball. The megatherium was very like the little sloth of to-day, but was nearly as big as an elephant. Instead of living in trees it stood on the ground and pulled the branches down for food.

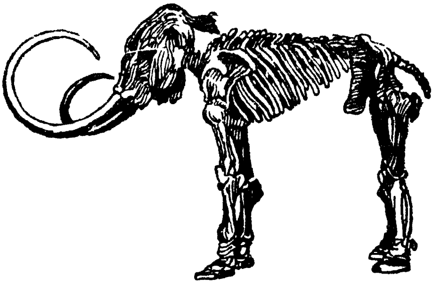
The mylodon, which lived at the same time as the megatherium, was not quite so big. It was supposed to be long extinct when a discovery in a vast cave in Patagonia proved that it had survived into quite recent times. In this cave a great piece of skin was found, dry but not decomposed, covered with hair and studded on the inner side with pieces of bone. Further exploration revealed the skeletons of about twenty mylodons, quantities of bones broken by human agency, and stores of dry grass. The most likely conjecture seems to be that the mylodons had been kept there by Indians only a few centuries ago to serve as food.

Australia, cut off from the main stream of mammal evolution, is characterized by its pouched mammals, which elsewhere, with few exceptions, died out as the higher types appeared. Fossil remains show that among the extinct forms were kangaroos twice as big as the present ones, and wombat-like animals as large as a moderate-sized elephant.

Among the extinct predecessors of the elephants we find the mammoth, the mastodon, and other less familiar forms.

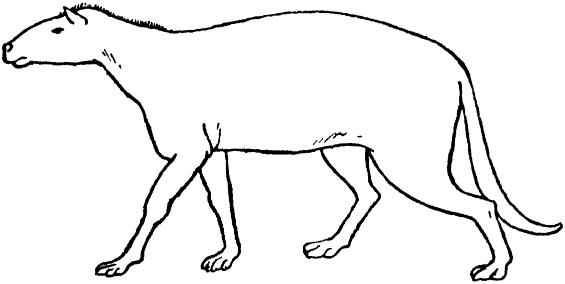
The mammoth, which had a much wider range than the elephant of to-day, resembled the Indian elephant, but was slightly bigger, covered with coarse hair, as are the new-born young of existing elephants, and with tusks displaying a somewhat different curve. Its tusks and teeth are frequently dug up in England, and in North Siberia whole carcasses are found in a frozen condition with the skin, hair, trunk, and soft parts complete.

The mastodon was very like a true elephant, but had slightly different teeth and a longer head and jaw. It survived into comparatively recent times, and its remains are commonly found in a very complete state in North America. Some of the older species were probably the ancestors from which elephants sprang. One of these has no tusks in the upper jaw, but two huge ones in the lower jaw. An elephant-like creature about the size of a horse appears to be a sort of connecting link between the elephant species and more ordinary mammals. Another smaller skeleton, though undoubtedly that of a member of the elephant stock, had probably no trunk at all and small tooth-like tusks. The cheek teeth of this creature have the few transverse ridges characteristic of those of mastodons. In later elephants the ridges became narrower and



SKELETON OF MAMMOTH

increased greatly in number, the mammoth having twenty-two, and the Indian elephant as many as twenty-seven. This increase in the number of ridges and other peculiarities in the teeth, the development of trunk and tusks, and shortening of face were specialized features produced during the evolution of elephants and leading them farther and farther away from the ordinary mammal type, to which we find the earliest representatives of the stock bear much more resemblance than the later.



An Ancestor of the Horse

With four toes on the fore feet and three toes on the hind feet

The most marked divergence from the typical five-toed mammal produced during the evolution of the horse is the reduction of the toes to one on each foot. All the horse-like animals probably sprang from an extinct stock which had five toes on each foot. A considerable step in the evolution of the modern horse was made by a little creature known as eohippus, which is only eleven inches high. This has four toes in front and three behind. In later beds we find horses which had three well-developed toes on each foot, each with a hoof resting on the ground. Then we have a horse with three toes on each foot, but the side toes are small and do not reach the ground and are evidently on their way to disappearing. Present-day horses occasionally 'throw back' to their three-toed ancestors by being born with these small side toes. Twelve stages have been recognized showing the gradual evolution of the modern horse. Besides the main line of descent which produced existing horses and zebras there were several side branches which became extinct. Accompanying the development of the special peculiarity of one-toed feet we find other changes of structure taking place in the horse by which it became better fitted for its environment. The neck grew longer, enabling the animal to graze on short grass; limbs became adapted for swifter motion and the teeth for more efficient chewing, and the general improvement in organization was accompanied, as often, by great increase in size.

Man, the crown of mammal evolution, dominates this earth more completely than any other animal that has ever existed. The most important human fossil remains take us back some 150,000 years, and show that man was at that date living in Europe in a savage state with the mammoth, cave-hyena, cave-lion, woolly rhinoceros, reindeer, and bison.

CHAPTER XI

MAN

FROM the earliest living material, the primeval grain of protoplasm that came to earth we know not how, some million forms of life have evolved, the lower and simpler forms being ever succeeded by the higher and more complex. From the green cells that multiplied on the tepid mud that fringed the oceans came all the plants that have existed in the past and that now clothe the dry land or live in the water. Family after family arose, more complex and more perfect in structure than those that had preceded it, and dominated the plant world until another appeared with some adaptation to environment which made it better fitted to thrive and multiply. At last the higher flowering plants, the crown of plant evolution, came, with their varied and exquisite devices for securing the continuance of their species, dominated all the earlier evolved families, and filled the earth with their beauty.

From the single cells that were the first animals came all the families that, increasing in complexity and perfection of structure, successively dominated the animal world—all from first to last dependent upon plants for their life. Man, the highest manifestation of life upon this earth, arose from the same lowly beginnings as the humblest form of it. So much the more wonderful is his development at its highest.

" Man," says Darwin, " bears in his bodily structure clear traces of his descent from lower forms." He is formed on the same general plan as other mammals. His bones can be compared with the corresponding bones of a monkey, dog, bat, or whale. Going outside the special group to which he belongs, we find the most striking structural resemblances through all the backboned animals. The arm of a frog, the wing of a bird, the fore-leg of a dog, the wing of a bat, the flipper of a seal, and the arm of a man are essentially the same, not only in bones but in muscles, nerves, and blood-vessels. Environment has resulted in the evolution from the same structural plan and out of the same material of the form of limb that will serve its possessor best. That the brain of all animals should have arisen probably out of a habit formed by worms of moving with one part of the body always foremost is not more difficult to conceive than that the first glimmerings of animal intelligence should have developed by infinitely slow stages into the highly organized brains of birds and mammals or that the brain of modern man should differ as greatly in power as that of a Newton, for instance, from that of an Australian aboriginal.

Man's first origin among the mammals is obscure, but there seems no doubt that he sprang from the stock from which lemurs, apes, and monkeys are also derived. His nearest relations are the man-like apes, the gorilla, chimpanzee, gibbon, and orang. He is not descended from these but from a stock common to him and them, and apart from his adaptation to an always upright gait his skeleton is essentially identical with theirs.

The ancestors of all the mammals, as has been said, were probably little lemur-like tree-dwellers living in swampy forests. Their descendants who clung to the forest instead of taking to a life on the plains gave rise to ape-like animals from which were derived monkeys, apes, and, in all probability, man. Just as all the mammal group arose with a tendency to great increase in the size and complexity of the brain, so, we may reasonably believe, in a particular branch of the stock from which the ape-like animals all arose this tendency was so strong that it produced a brain incomparably superior to that of any other animal, and thus made man. Development in the apes and monkeys took the form of a slow improvement in the brain and a great increase in the power for offence and defence of jaws, teeth, and arms Man's intelligence taught him to fashion and use more effective weapons than his natural ones, and his development along ape lines was checked.

LEMUR

The fossil remains of the early forest mammals show that most of them at any rate were essentially similar to the lemurs which still exist in the forests of Southern Africa, Southern Asia, and Madagascar. Modern lemurs are small, but the skull of one extinct species is fifteen inches in length, and many lemurs which survived till recent times were comparatively large. They vanished from the Northern Hemisphere early in mammal history, and in the southern parts of Europe and North America their place was taken by monkeys, animals of distinctly greater brain-power.

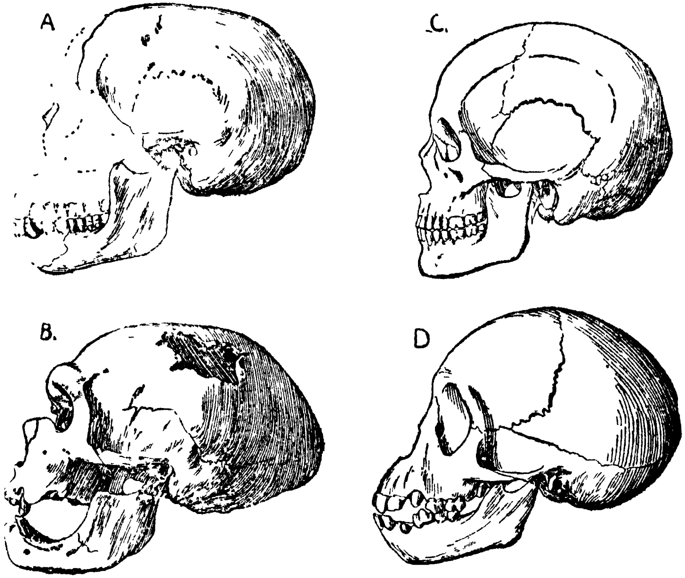
American monkeys differ from those of the Old World in their teeth, their prehensile tails, and the flattening and widening of the nose. They never produced great apes or made any approach to the human stock. All the Old World monkeys resemble man in their teeth and in their comparatively narrow nose, with the nostrils opening downward. None of them have prehensile tails, and many have no tails at all. One family, the man-like apes, represented at the present time by the gorillas and chimpanzees of tropical Africa, and the orangs and gibbons of South-east Asia, resembles man very closely in many respects. In the earlier days of the family it spread as far north as the middle of Europe, for the fossil remains of several man-like apes are found in the rocks of France, Northern Spain, Germany, and Austria. The climate of Europe cooled, becoming temperate and then passing through an ice period, and the apes retreated southward to warmer lands. As they disappeared from Europe long before the appearance of man, it is in the rocks of more tropical countries that we must look for the links between man and the early apes. So far only one discovery of this kind has been made in the tropics, and the interpretation of the remains found in river-drift in Java remains doubtful.

They consist of the roof of a skull, two grinding teeth, and a thigh-bone, and they are considered by some to represent a link between the gibbons and man. The roof of the skull is very like that of the existing gibbons of Java. It has a low crown and prominent brow-ridges, but it is almost as large as the skull of a small man and the brain capacity is almost human. On the other hand, the teeth are more like those of a gibbon than those of a man. The thigh-bone is adapted for upright gait, but is not completely human. It is doubtful whether these fragmentary remains are those of an ancestral man or of a very large and highly developed gibbon. The direct progenitors of man have yet to be discovered, but somewhere the rocks hold their remains, as well as those of the ancestors of men and apes alike.

Even the largest man-like apes are much inferior to man in brain capacity. In modern Europeans this averages 1480 c.c.; in the largest known gorilla it is not more than 600 c.c. Brain development is often found accompanying increased powers of balance and locomotion, and man's adoption of an upright gait was probably the most decisive step in his evolution, since it freed his hands first to fashion and use weapons instead of being dependent upon his own jaws, teeth, and muscular grip for fighting purposes, and secondly to acquire in due course all the manual arts. As he gradually formed the habit of fighting his enemies with stones and clubs the great canine teeth which are characteristic of apes and monkeys would become reduced in size, and the jaws would be modified so that articulate speech became possible. Adaptations of structure would take place as an upright posture became habitual, rendering it more easy to maintain, in particular, a curving of the backbone and a poise of the head different from that of apes. In the man-like species, though an upright gait is possible, the straight spine, the overweighted front portion of the head, and the over-developed arms cause them to vary in their mode of progression between the use of hind-legs only and of all-fours. Lastly, though they have been known to unite in repelling an attack, the man-like apes do not, as some monkeys do, live in societies, and it is man's social habits that more than any other factor in his development have tamed and civilized him. Throughout the animal world it is, generally speaking, the creatures that live in communities, such as most bees and wasps, ants, beavers, wolves, and elephants, that display the most wonderful instincts and sometimes the greatest intelligence, and the history of man's still incomplete civilization is to a great extent that of the widening of his community feeling, and the deepening of his sense of brotherhood. The family affections, the emotions of pleasure, pain, joy, sorrow, fear, suspicion, jealousy, the qualities of courage or timidity are all common to man and the more highly organized animals. Outside these all the higher developments of the human mind are created by association. Men sacrifice themselves for the community and for one another at the mysterious prompting of an unselfish love. For the general good they submit to law. Because some men are driven by an impulse within them to express to others their sense of truth and beauty the arts arise.

The apes had retreated southward before the increasing cold of Europe. Somewhere, it is likely in tropical countries, man evolved, and when the ice epoch was over, and probably before, he was in Europe, no longer, like his ancestors, taking the line of least resistance and making no fight against Nature, but combating her rigours, not by slow adaptation to environment, but by means which his own brain had devised—by clothing and by fire. Thus he survived great changes of climate, and it is certain that man has existed in Western Europe for a long period during which many wild animals died out. He had reached the southern part of England long before the British Isles were separated by the sea from the mainland of Europe.

This was proved in 1912 by the discovery of portions of a skull and lower jaw in a river gravel at Piltdown, midway between Crowborough and Lewes in the Sussex Weald. Since the laying down of this gravel the geography of the district has entirely changed, and the river that left it has either changed its course or completely disappeared. It is not often that so ancient a gravel is preserved, and any fossils found in it would therefore be of great antiquity and value. Some of

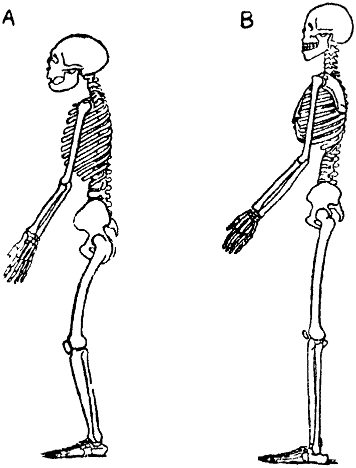


A Left-side View of the Piltdown Skull. B. Left-side View of Skull of a Primitive Type from La-Chapelle-aux-Saints. C Modern Human Skull. D Skull of a Young Chimpanzee

Reproduced by permission from "A Guide to the Fossil Remains of Man," British Museum (Natural History) these are older than the gravel itself and must have been washed into it from earlier rock layers. They consist of portions of teeth of the mastodon, of an early elephant, and of the rhinoceros. Some teeth of hippopotamus and beaver and part of the antler of a red deer are probably of the same age as the gravel itself. There are also flint implements, some exceedingly primitive and, like certain of the fossils, older than the gravel; the others, which are roughly chipped, are almost certainly of the same age. The condition of the human remains has caused them to be assigned to the same period as these, and Piltdown man appears to be one of the earliest specimens of the human race that the rocks have so far revealed to us.

The skull, in spite of ape-like peculiarities, is on the whole absolutely human. The forehead is as steep as is usual in modern man, and without the prominent bony brow-ridges characteristic of apes. The face must have been unusually large, and the skull very broad in proportion to its length, but the brain cavity is 1300 c.c., which is equal to that of the smaller human brains at the present day. However, while the skull is completely human, the lower jaw is almost exactly that of an ape, though its greater width probably made articulate speech possible. The teeth are human in type though rather large, but the canine teeth probably interlocked in ape fashion.

Piltdown man therefore appears to have been one of the early forefathers of the human race. His remains show that man acquired his characteristic brain and skull before he had advanced sufficiently to substitute craft and invented weapons for the use of teeth in the struggle for existence. A lower jaw, retreating and ape-like, but with teeth resembling those of some of the lower races of existing men, and with canines neither large nor prominent, was dug up in 1907 near Heidelberg in river-drift where there were also found bones and teeth of the types of horse, bear, elephant, and rhinoceros which were living when the Piltdown gravel was formed. This shows that men of much the same type as Piltdown man were living in Europe during the same period.



A, Diagrammatic Restoration of Skeleton from La-Chapelle-aux-Saints compared with B, Skeleton of existing Australian Man

In A the shoulder-blade is wanting

From "A Guide to the Fossil Remains of Man" (B.M.), by permission

Somewhat later there appeared in Europe another race of men, whose skeleton is almost completely known from remains discovered from time to time. They are f[illegible] in association with flint implements elaborately chipped on one face, and with the bones of the mammoth, bison, woolly rhinoceros, cave-lion, and reindeer.

All the skulls are characterized by great bony brow-ridges which produce a retreating forehead like that of existing apes. The brain cavity, however (about 1626 c.c.), is larger than that of the average European of to-day, though the brain may have been of inferior quality. The jaws and teeth are quite human, and the only peculiarity in them is the absence of any bony prominence in the chin.

For some time this primitive race of men was contemporary with a much higher one which was in existence before the mammoth and woolly rhinoceros became extinct. The skulls of the latter race are as highly developed as those of the average European of to-day and their whole skeletons were in no way inferior. The existence of well-defined chins in these specimens emphasizes the extreme antiquity of those in which any bony prominence is lacking. The lower race died out or disappeared from Europe, and the higher one persisted and was the ancestor of our own.

Thus, though the facts at our disposal are scanty, we find that in proportion to the age of the rock beds in which human remains are found the more traces they retain of an ancestry related to the apes. They suggest descent from an ancient forest mammal, the special characteristic of which was an abnormal development of brain.

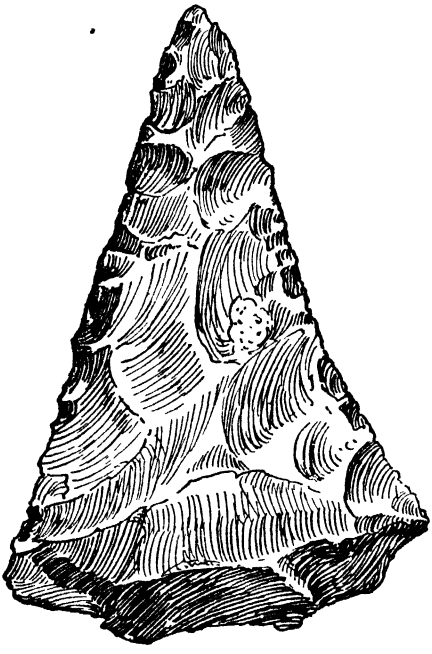
CHAPTER XII

THE EARLY USERS OF STONE

OF the conditions in which, long before the dawn of history, early man lived on the earth we know little that is certain. The first traces of his existence are the weapons and domestic implements of chipped flint that he learnt to make thousands of years before he became a worker in metals. Some of these, from the geological beds in which they are found, would make the presence of man in Western Europe date back farther than is generally accepted. It is a matter of dispute, however, whether their chipped condition is due to primitive human workmanship or to natural causes, such as a torrent sweeping them over a rocky bed. Even where the chipping is undoubtedly man's work it cannot always be dated from the position in the rocks where the flints are found. This is usually at various depths in the gravels of the present river system, but in many cases the condition of the flints is proof that they have been washed into their present situation from an older rock formation. As has been said, the land surface of the earth is in a continual state of unmaking and remaking. The hills being most exposed to weathering and denudation are gradually reduced, and their material laid down as sand and gravel along river beds. These may be raised so much by the accumulation of *débris* and by earth movements that the river has to abandon its old channel and begins to cut out a new valley. Thus in the course of ages hills become valleys and valleys become hills.

During the geological epochs that witnessed the evolution of the modern mammal species we have evidence that North-west Europe underwent a transition from tropical to temperate, and afterward to glacial conditions. During some of the time a great part of England was sunk beneath the sea to a depth of about five hundred feet, and afterward raised to much the present level. The North Sea and the English Channel did not exist, the north-west coast of Europe stretching to the 100-fathom line west of Scotland and Ireland. While it was submerged, and afterward, the climate continued Arctic, and after the upheaval the northern part of Great Britain was buried beneath an ice sheet from 1500 to 3000 feet in thickness. This did not reach south of the Thames, and in the eastern counties of England as many as four different layers of rock *débris* left by melting glaciers are sometimes found, showing that during the Ice Age there were milder periods in which the area of perpetual ice moved northward.

The oldest flint implements are usually found either in deposits left by glaciers or in river deposits laid down when the Ice period had passed. It is often difficult to distinguish between these, and thus it cannot be said to be established beyond dispute whether man was living here and in North-west Europe before the period of intense cold set in, and, if he was, whether he survived its rigours. The discovery, however, of Piltdown man points to a very early appearance of the human race in this part of the world, and flint implements are sometimes found in association with the bones of animals, including the stag, roe-deer, cave-bear, horse, hippopotamus, straight-tusked elephant, and urus, which we know existed here before the Ice Age, since their remains occur in rocks formed earlier.



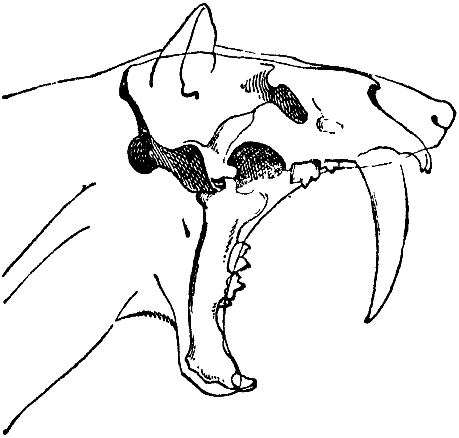
PALÆOLITHIC PICK

Buried in river-borne deposits, perhaps a dozen feet below the present surface of the earth, we often find the level on which the men of the Old Stone Age lived and worked. Where there was a supply of flints for the weapons which were all they had with which to face the mammoth and the rhinoceros we sometimes come across the workshops where those who were skilled in the art of fashioning them pursued their calling. There are the finished implements, the rough flakes, the heaps of unworked flints, the hammer-stones, just as ancient man left them when a flood came and buried the materials of his craft in a layer of gravel and mud. It was probably a very early flint-worker who, watching the sparks fly as he struck flakes from the core with his hammer-stone, made the greatest of all the material discoveries in the history of men—the art of getting fire.

We can trace in the flints the gradual development of man's skill and of his wants. We find at first no implements deliberately chipped. Fragments and flakes of flint have been adapted to the purposes of hammering, cutting, piercing, rubbing, and scraping. Then we come across clear and more or less successful attempts to make a certain pattern of tool from a fragment of flint. Weapons are invented next, and man, who had hitherto trapped and pursued with stick and stone only the smaller animals, and fled from the greater, now found that, armed with his flint daggers, axes, spears, and harpoons, he could hunt the stag and the antelope, and was not entirely helpless against the dreaded mammoth, rhinoceros, hyena, jackal, and wolf. The skilled worker in flint would be a man of mark in a community of Old Stone men.

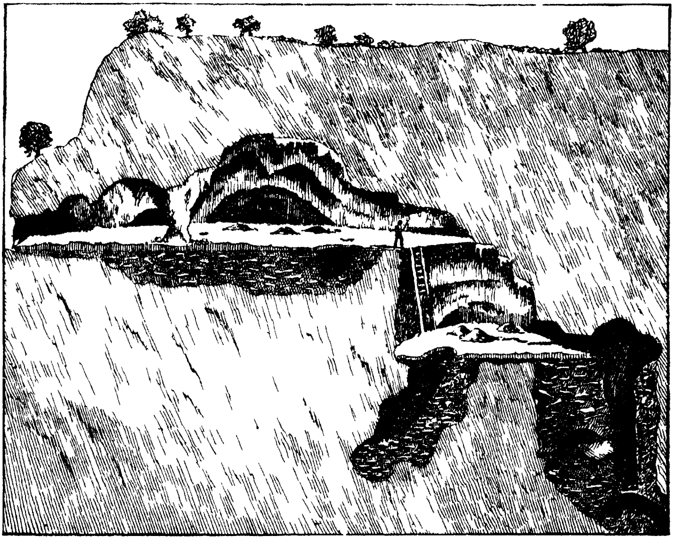
Caverns in limestone rock produced by rivers and underground streams, and recesses in cliff-faces overhung by a ledge of rock, provided shelters from which, no doubt, man often ousted the cave-bear, hyena, and lion, the wolf, and the fox, defending at night the approaches to his hard-won dwelling by fire, that invention which put the strongest animal at a disadvantage. Often, no doubt, some catastrophe put an end to the human occupation of a cave, and wild beasts resumed possession of it until man, their puny but subtle enemy, dislodged them again. Remains of extinct carnivorous animals found in such places show that some of them were of extraordinary size. The skull of a cave-bear is almost two feet in length, and the skulls of the cave-lion and sabre-toothed tiger are much larger than those of their modern representatives. No doubt Ancient Stone man, the hunter, was often enough the pursued and the prey.

Probably he liked his shelter to be difficult of access, for there were human enemies to be feared as well as wild beasts, and preferred it when it was high above the level of the river which had formed it, especially as it was then less likely to be flooded. But when caves were the only houses any cave would in most cases be desirable, and we know from the mud deposits and what they contain that the flooded river sometimes drove our Old Stone man to escape in haste, leaving behind him all his belongings, his dressed skins, his ornaments, the meat he had killed, and, bitterest loss of all, his flint axes and knives. Such caves, once accessible to the flood, are now often high above water-level, the river having in some cases hollowed out its valley an additional hundred feet, a result that it would take an enormous period of time to achieve. Usually they are almost filled by silt, deposited during floods or by the trickling of streams through the roof above, and



HEAD OF SABRE-TOOTHED TIGER

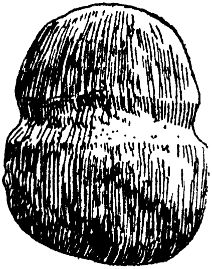
by blocks detached by the action of water. As soon as the entrances were closed they and their deposits were sealed up, until some of them were explored in recent times Because what they contain has been thus preserved we are able to see a little more clearly



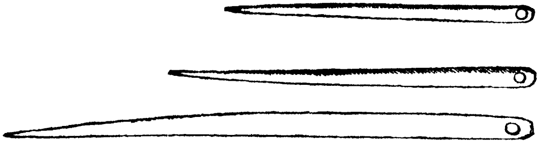
A Cave Dwelling of the Stone Age (Section)
From "Cave, Mound, and Lake Dwellers," Holbrook (Heath)

into the dim past of prehistoric man; we can trace in general an improvement in his craftsmanship; we find an occasional falling off; we perceive from the absence of certain things in the later deposits that had been common in the earlier that a change in conditions had taken place which was perhaps leading to the disappearance of Old Stone man before a new race and a new way of life.

Digging into the floor of a cavern that for a long period served as a shelter for cave-man and for beast, we come upon quantities of the bones of the animals that haunted it, many of them gnawed by the cave-hyena, bones of antelope, roe-deer, and other animals hunted for food, split by man to obtain the marrow, and some showing traces of fire, often the remains of hares in such great quantities that they must have formed the chief food of the men who found shelter here. There is a patch of charcoal several yards square and many inches thick where they cooked it, and when the human occupation has been intermittent we find several hearth-stones and layers of charcoal separated by beds of *débris*. In that case the implements found with the different charcoal layers will probably show an improvement in the skill with which they have been made. Often the hearthstones have formed resting-places for unburnt or partially burnt human bodies, after which probably the cavern was abandoned for a time, or finally when accumulations of refuse had raised the floor too near the roof for further habitation. In one case at least skeletons have been found only four feet from the rock overhead.


HAMMER-STONE

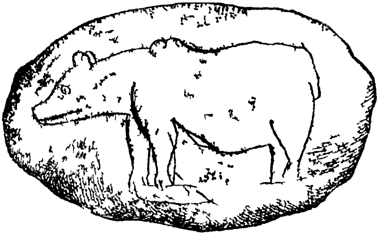
Old Stone man reached a high pitch of skill in the working of flint. There is immense advance shown from the roughly chipped tool, hardly to be verified for certain as the work of man, and the leaf-shaped point or point with shoulders which in proportion to size served as an arrow-head, lance-head, or knife. Flakes of flint were finely worked to serve as planes, or as instruments for scraping skins. Quartzite pebbles with hollowed faces were possibly used as anvil-stones for flint working, or, some hold, as mortars for grinding colour—for cave-man was an artist as well as a hunter. Tools and weapons of bone followed those of flint, and are found along with them. The antlers of the reindeer especially were worked into spear-heads, sometimes with plain points, sometimes barbed like a harpoon, and with the base split to receive the shaft, or cut like a wedge to fix into it. Other bones perforated with round holes were possibly whistles. The craftsmanship of Old Stone man is shown best of all in the bone needles he made for the sewing of skins, scraped and manipulated probably in Eskimo fashion, so that they remained soft. For these he took a splinter of bone which he rounded with a flint scraper. Then he rubbed it smooth and tapering with a sandstone burnisher, and lastly drilled an eye in it with a pointed flint.



Bone Needles

From strings of teeth and periwinkle shells and medallions of bone and ivory we know that cave-dwelling man, in the midst of an existence which was for ever that of hunting or being hunted, a perpetual struggle against hunger, cold, and enemies of all kinds, had already an eye to the adornment of life, that he took pleasure in hanging on himself and, we will hope, on his womankind necklaces of anything that he thought would add to personal attraction.

As developing intelligence made him more and more aware how precarious was his hold upon existence, and set him speculating whether it was not some unseen hostile power that made his hunting fruitless and thinned the numbers of his tribe by agues and fevers, he began to look to brains more subtle than his own to devise plans for defeating his enemies and for bringing to naught, by the use of incantations and magic, the evils that threatened him At any rate we sometimes find strange-looking sceptres formed of an antler pierced with circular holes, which may have been emblems of rule, or magicians' wands. They seem to indicate that already man was displaying the general human tendency to shift responsibility and to set up authority.



Cave bear drawn on a Pebble found in a Cave in France

From "Cave Mound, and Lake Dwellers," Holbrook (Heath)

One great resource early stone man had by which he could divert his mind from the pangs of hunger, or while away the days when hunting was impossible—he was an artist—a sculptor, an engraver, an admirable draughtsman The human figure and the animals he hunted—not as a rule those which he dreaded for their strength and ferocity—were the subjects he tried first to represent, and these he sculptured in the round on mammoth tusks, pebbles, bones, and pieces of reindeer antler. Hair and other details he put in with a flint graving-tool, and from this he soon came to engraving an outline on pieces of antler and scraping away the ground to throw it into low relief. Pure engraving on ivory and bone followed, the subjects being single animals, or groups, sometimes hunting scenes. The human figure he seems consciously or unconsciously to have caricatured ; animals he usually delineated with enviable spirit and sureness of touch. Among the animals, often extinct at the present day, that he portrayed are the mammoth, the urus (the great ox that Cæsar describes), the reindeer, ibex, horse, goat, and occasionally fish. The prehistoric artists varied naturally in skill, and an interesting contrast is afforded by two engravings on stone of oxen by different hands, the one masterly in execution and expression, the other with its scratched and uncertain outlines suggestive of a work of art produced in a modern nursery.

Recently there have been discovered at least twelve caves in France and Spain the walls of which have been decorated by prehistoric artists with representations of animals and men. These are sometimes engravings, sometimes paintings in black, brown, or red, the modelling of the figures well shown, and high lights scraped.

This early development in man's history of art of a high order is one of the wonders that the study of life abundantly provides. Cave-man's skill in depicting animals vanished, however, with him, and man of the New Stone Age, though a better craftsman, was a worse artist.

CHAPTER XIII

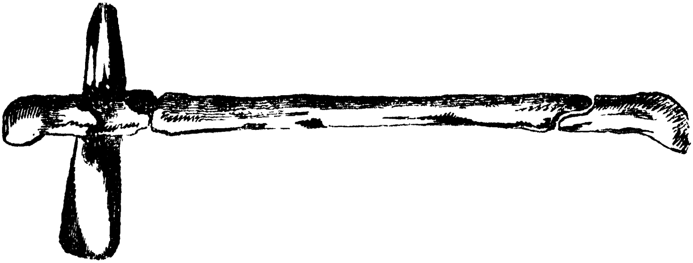
THE LATER USERS OF STONE

HOW the Old Stone Age passed into the New Stone Age no one can say. On the sites where New Stone man had his dwelling we find relics denoting a different and more advanced manner of life; but when or how or where it first replaced the old we have at present no means of knowing. In caves inhabited during both periods we often find the remains separated by deposits that must have taken an immense length of time to form. This is held by many to be a sufficient proof that the Old Stone Age was separated from the New by a great gap—that Old Stone men for some reason vanished altogether, and the new way of living was introduced by a new race. Others maintain that, though many settlements were for unknown reasons deserted, a remnant of the ancient population—dwellers probably not in caves but in the open—remained and mingled with the new, handing on to them certain of their physical peculiarities and the traditions of the flint-flaking industry. In Western Europe the moist cold of the early cave period, during which the mammoth flourished, had given place to the dry cold of the later, and that again at the beginning of the New Stone Age had been succeeded by a moist and temperate climate. The mammoth was extinct, and the reindeer and other Arctic animals had migrated north, followed perhaps by the population of the caves, and now that tusk ivory and reindeer antler were no longer available carving in those materials was at an end. Flint-flaking, the first human industry, remained, to assume new forms and to give a name to the second period in the history of the race.

By the time that New Stone man was making his implements of ground and polished stone, change of climate and earth movements had transformed the face of Europe. Great subsidences took place in the north-west. The waters of the Atlantic filled the valley where the English Channel now is, and flowing in on the north divided Scandinavia from the British Isles, formed the shallow North Sea where dry land had been, and at last joined themselves by the Straits of Dover to the long inlet sundering England and France. The ice sheet had gone, except from the highest mountains, leaving behind it rivers and lakes and great stretches of fen, uninhabitable except for swans, geese, herons, and other marsh birds. The mammoth was extinct, the elephant, hippopotamus, rhinoceros, and lion had vanished, the reindeer had wandered away in search of colder climates; but the forests that clothed a great part of the land gave cover to the wild boar, the wolf, and the grizzly bear. In the dry, open, grassy country, such as Salisbury Plain, the Downs, and the Yorkshire Wolds, were the settlements of New Stone man.

The use of polished stone is sometimes regarded as the distinguishing mark of the New Stone Age, but a great many implements and weapons, such as knives, arrow-heads, scrapers, and even axes were frequently finished by chipping alone, without any grinding or polishing. In the case of many implements, such as the rude tools used in agriculture, such operations would have been a mere waste of time. The development in the stone industry lies not only in the grinding and polishing which enabled other stones besides flint to be used, but in the greater variety of forms, and in the hafting which had become general.

It was not, of course, only in the manufacture of weapons and tools that New Stone men advanced beyond their predecessors. They were no longer dependent entirely upon hunting for their food. They practised the art of agriculture, and grew wheat, barley, and millet for food, and flax for clothing, for they had learnt to spin and weave both flax and wool. They tamed the horse and dog, and kept sheep, goats, cows, and pigs to provide milk and meat. The long-bow, a great advance upon javelins, spears, and axes, was in use. Pottery was made; and instead of rude natural shelters houses were often built of wattle and mud, and raised on piles in lakes and rivers to secure them against attack. The importance attached to the burial of the dead, and the raising of great monuments, such as Stonehenge, perhaps indicate the growth of religion and the belief in a future life.



STONE AXE HAFTED

It must not be thought that all over the world the new arts were known and practised at the same time. This was not the case even in Europe, which received them from tribes migrating from various localities and bringing with them varying customs and degrees of civilization. Those coming from the valleys of the great rivers, which are the natural highways of the world, and consequently the regions which soonest become acquainted with improvements in the arts of life, would be more advanced than those emerging from less favoured districts, and again their further advance in civilization would depend to a great extent upon the natural advantages of their place of settlement.

Just as no definite date can be given for the beginning of the New Stone Age, so no general date can be assigned to its close. It overlapped a fresh epoch in which the use of copper and bronze was to supplant that of stone, but this overlapping began at very different dates in different parts of the world, and is even in some remote regions going on at the present day. In Northern Europe the New Stone Age came to an end about 2000 B.C.; but as early as 2500 B.C. copper was being worked in Cyprus; while in Egypt it was in use before 5000 B.C. On the other hand, long after the discovery of America the Indian tribes continued to use implements such as were made in Europe during the New Stone Age, and savage man at the present time is almost everywhere in the same stage of civilization, and employing the same devices to supply his wants. When we find a primitive people living in conditions of climate and surroundings similar to those of New Stone man in Europe we are pretty safe in believing that their household utensils, clothing, manner of life, and even their ways of thought are much the same; and we can reconstruct, as it were, that part of the existence of primitive man which, from its nature, has been unable to endure in Europe to our day. The natives of New

Guinea, Australia, and New Zealand, the Eskimo of the Arctic region, and the Bushmen of South Africa can teach us a great deal about our own past.

Among a people entirely ignorant of the working of metals, and dependent for all their weapons and tools upon stone, the working of flint would naturally be the most important industry, and regular mining for it was carried on during the New Stone Age. The best flint is found in seams lying at irregular depths in the chalk, and, generally speaking, the finer quality is found at the greater depth. Shafts as much as forty feet deep were sometimes sunk in the chalk, and galleries tunnelled along the flint seams, connecting pit with pit. To light his way along them the miner carried a lamp carved from a lump of chalk. His tools were rough flint implements made on the spot, and pick, punches, and chisels of deer-horn. The shoulder-blades of an ox have been found in one mine, having apparently served as shovels, and on a deer-horn pick from another there is a smear of chalky clay, still keeping the thumb-print of the very miner who wielded it many thousands of years ago. At some flint centres the flint was not only mined but manufactured on the spot, and a regular trade in flint implements carried on with a wide district.

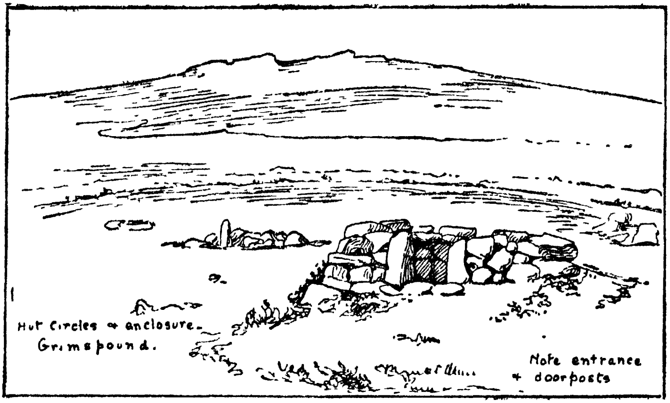
MINER'S PICK OF DEER-ANTLER

There are signs too of a division of labour, as in modern manufacture, a large number of implements in the same stage of making being found together.

A good deal about the dwellings of New Stone man can be gathered from those built by primitive men at the present time, and from the remains of prehistoric lake-dwellings, the foundations of hut settlements, and the long barrows, or tombs, which were really houses built for the dead on the pattern of those intended for the living. These tombs, which were probably built for chieftains, consist usually of a single roughly made stone chamber, often with a rounded entrance at one end, and approached by a passage, the whole covered with earth, as the Eskimo cover their winter houses at the present day. The barrow usually points east and west, the eastern end being broader and higher than the other. One excavated near Avebury was 336 feet long, 75 feet wide at the east end, and 40 feet wide at the west. All round the foot of the barrow there was originally a line of upright stones, the spaces between filled with dry walling, and the chamber and passage were roofed with stone slabs weighing about a ton each. Within the chamber were four long-headed skeletons, probably of the chiefs for whom the tomb was constructed, but others were found denoting that it had been opened from time to time for later burials. Cremation does

VIEW OF LONG BARROW

not seem to have been the practice at the beginning of the New Stone Age, but where a barrow has been reopened it sometimes contains bodies which have been burnt as well as bodies which have not. Another type of tomb was the dolmen (table-stone), a structure consisting of a large stone supported usually on three upright ones erected on the grave.


Hut Circles & enclosure. Grimspound.
Note entrance & doorposts

Hut Circles

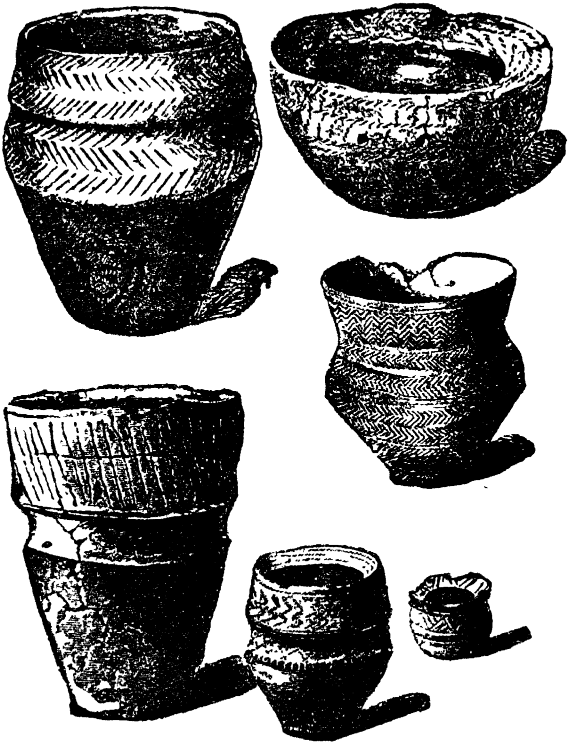
From "Child Man in Britain," Ashford (Harrap)

It was not usual in early burials of this period to provide the dead with the things that had been useful or dear to them in life. Nevertheless we do find in barrows, perhaps as the result of many successive interments, flint celts (*i.e.* axes of chisel form), axe-hammers, javelin- and arrow-heads, implements of various kinds, food-bowls, beads, and pendants, and flint and iron pyrites for striking a light. The sacrifice entailed in burying these to a primitive people unencumbered by many possessions must have been due either to a reluctance to take from the dead the things that had been peculiarly theirs, or to a desire to furnish them, when they awoke from their long sleep, with the means of resuming the existence they had known on earth. All care spent in burying the dead is in fact due to the belief in a life after death.

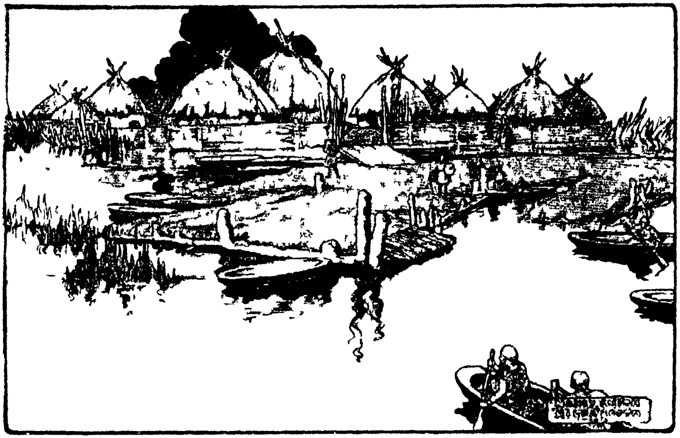
The hut sites of New Stone man's settlements may be found in many parts of England on dry, open ground that has never been ploughed. They are little circular pits, about four feet deep and about fifteen feet across the mouth. Digging through the deposits which have accumulated upon the prehistoric level we come to the black band, from three to thirty-six inches deep, of cinders and charcoal interspersed with bones, flint implements, and broken pottery, which is the hearth where the hut-dwellers cooked their food. Round the pit there was once a wall of earth, and from the middle of the floor rose a pole supporting a roof of thatch or branches. Often the number of hearths denotes quite a large settlement, and round the whole village there was probably an earthen wall and a ditch for defence. Near by, the dew-pond, where the cattle drink to-day, was made long ago by the pit-dwellers to hold rain and dew for the water-supply of themselves and their cattle.

Caverns and rock shelters still served sometimes for New Stone man, as they had done for his predecessors of the Old Stone Age. They represent the most primitive form of dwelling, the pit settlements a sort of middle stage, and the lake-dwellings that were constructed in many parts of Europe, but more especially in Switzerland, the greatest advance in house-building attained by the later users of stone.

Hippocrates, writing in the fifth century B.C. of the people of the Phasis, a marshy country subject to frequent floods, says that they live in houses of timber and reeds built in the midst of the waters, and use boats made of a single tree trunk. Herodotus, also writing in the fifth century B.C., says that the people of Lake Prasias live in houses constructed on a platform supported by piles in the middle of the lake and approached from the land by a narrow bridge. Such were the lake-dwellings of the New Stone Age, and such to-day are the settlements in the Gulf of Maracaibo, the estuaries


NEOLITHIC AND BRONZE AGE POTTERY

of the Orinoco and Amazon, and the pile-villages of New Guinea. The Rumelian fishermen of Lake Prasias still build their houses in this way, and in Switzerland the lake-dwellings continued in use right through the Bronze Age into the early Iron Age. There were fifty in Lake Neuchâtel, thirty-two in Constance, twenty-four in Geneva, and twenty on the Lake of Bienne, where the largest spread over an acre and was connected with the shore by a gangway 100 yards long and 40 feet wide.



A Lake Village

From "The Threshold of History," Hall (Harrap)

The platform on which the houses were placed rested on piles driven into the bed of the lake, or sometimes on stacks of brushwood strengthened by piles, both piles and platform consisting of the unbarked trunks of trees. The walls, which were supported by posts, were of wattle and clay, the roof thatched with bark, straw, or rushes, and the floor of timber and clay. The hearth was a flat slab of stone. One such house measures 33 feet by 23, and is divided into two rooms by a partition. Others are 20 feet by 12, or 27 feet by 22. Even the smallest of them could give points as regards size to many a dwelling in civilized countries at the present time. The space between the dwellings was usually about three feet, and sometimes this was occupied by the stalls of cattle. Where the settlement was not connected by a gangway with the shore it was reached by canoes hollowed out of a single tree-trunk with the aid of fire by the chisel implements called celts.

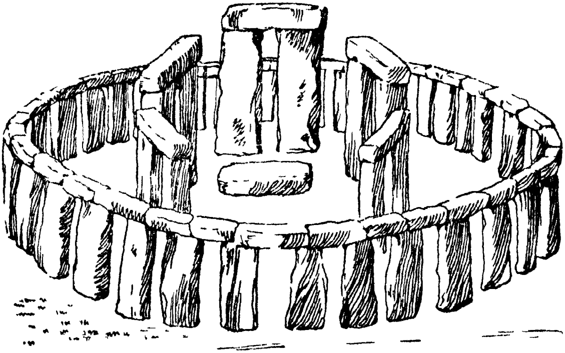
In the smaller lakes a deep layer of peat moss has often been formed, in which the more perishable objects have been preserved. The remains found on the sites of Swiss lake-settlements occupied in the Stone Age show that the domestic animals possessed by man were still few; oxen were numerous, but the horse, sheep, dog, and pig were rare. Among the wild animals of the region were the urus, bison, elk, bear, stag, beaver, fox, and hare.

The lake-dwellers did not depend alone upon hunting for their food. They cultivated wheat, barley, and millet, and made a coarse kind of bread, and had as fruits the raspberry, blackberry, pear, and apple. Their clothing still consisted largely of skins, but they grew flax and could spin and weave, and they produced both linen and woollen cloth. Many earthenware vessels, some covered with soot, have been found, showing that the potter's art had made great progress, though the potter's wheel was still unknown.

Among the implements that have come to light are polished stone axe-heads with hafting of stag's horn and wood, flint flakes, arrow-heads and saws, barbed harpoons of stag's horn, awls, chisels, bone needles and fish-hooks, and a skate made of the leg bone of a horse.

The lake-settlements reveal a mode of life that was neither unhealthy nor too straitened, and that had reached a reasonable stage of civilization.

Cromlechs, or circles of great standing stones, such as those of Avebury and Stonehenge, are characteristic of the New Stone Age and have, we can scarcely doubt, a religious significance. What the beliefs of primitive men of the Stone Age were we are hardly likely to discover, except by analogy with those of primitive men of to-day, but it has been argued with some probability that the stone circles have a connexion with sun-worship.

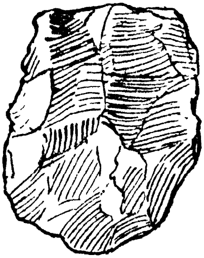


RECONSTRUCTION OF STONEHENGE

CHAPTER XIV

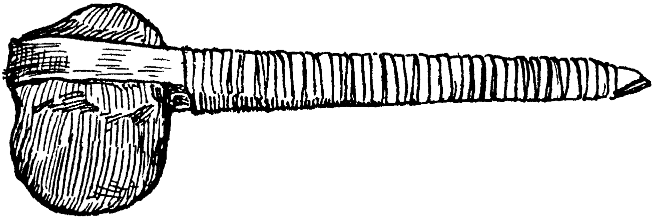
USERS OF STONE IN MODERN TIMES

AFTER the first and all-important invention of fire-making in the infancy of the human race—a discovery which established once for all the supremacy of man over the lower animals—the most important step in the evolution of civilized man was the beginning, at very different times in different parts of the earth, of metal-working. More than one primitive people had found out that copper, which often occurs in large metallic masses in the ore, can be fashioned into implements by hammering. This discovery alone did not lead to very much. It was the employment of fire in the reduction of metals that marks the striking advance in human knowledge that caused the abandonment of stone implements in region after region as the invention reached it. Those on the highways of intercourse naturally received it first. Countries which were inaccessible or remote from the metal-working districts passed from their Stone Age to the Age of Metals thousands of years after those more favourably placed. Stone tools were being used in Northern Europe and the British Isles at least three thousand years after copper was in use in ancient Egypt; with the exception of Mexico and Peru, which were already acquainted with copper and bronze, the two Americas went through the transition from stone to metal considerably after the voyage of Columbus in 1492. The majority of American Indians passed out of the Stone Age with the settlement on the continent of the English, French, Spanish, and Portuguese. Yet even at the present day the more backward Indians of the Amazon basin and many of the Eskimo tribes of the extreme North are in a stage of civilization similar to that which ended in the British Isles about 2000 B.C., while the natives of Tierra del Fuego and tribes such as the Seri Indians living on an island in the Gulf of California, who use shells for knives, cups, and dishes, and natural pebbles for hammers, and who place their dead in simple pits with the objects that belonged to them in life, are in at least as primitive a stage as the men of the Old Stone Age. We can find similar conditions still existing in many other parts of the world.


AN UNFINISHED STONE AXE-HEAD FROM AN ABORIGINAL WORKSHOP, QUEENSLAND

It is customary to term such primitive peoples of the present day savages, and to look upon them as entirely different from civilized men—as being lacking in certain qualities or capacities, and, on the other hand, as endowed with instincts which are useful, no doubt, but make them more akin to the lower animals. Those who have lived among them with open eyes, however, tell us that on a closer acquaintance the word savage ceases to have a meaning; they perceive that the so-called savage, like the civilized man, is the product of his environment, which is responsible for the fact that he is in some respects their inferior, in others their superior. They discover that it is not instinct that guides an Eskimo over an apparently trackless expanse of snow, or an Indian over a featureless plain, but observation, such as enables a civilized man to find his way home round corners and down streets that to an unaccustomed eye look all alike. They find among savages affection, honour, religion, manifesting themselves differently perhaps, but essentially the same feelings as they are in themselves, and, we may well believe, the same, even in many of their manifestations, as they were in our prehistoric ancestors of the Stone Age.

Some of the beliefs of these predecessors of ours we can almost certainly trace in literature and compare with those of primitive men of to-day. Take the invention of fire—the first great step in man's conquest of his material environment. Nobly enshrined in Greek literature we have the story of the titan Prometheus, the benefactor of the human race, who stole fire from heaven and thereby incurred the jealous anger and vengeance of the Father of the Gods. As told by Æschylus, it is a highly civilized rendering of some much more ancient fire myth, the germ of which is the theft of the great secret from some one unwilling to share the advantages derived from it. Some such fire myth appears to form part of the folklore of every primitive tribe of to-day.



A MODERN STONE AGE AXE FROM CENTRAL AUSTRALIA

This is one Australian version of a tale which has a different rendering in almost every tribe.

When the crane married the kangaroo rat there was no fire in the country. One day when the crane was rubbing two pieces of wood together he saw a faint spark fly out, and then a slight smoke. "Split your stick," said the kangaroo rat, "and place in the crevice grass and bark so that a single spark may kindle a flame."

After much rubbing flame sprang out, and so they discovered how to make fire. They determined to keep the knowledge to themselves, but suspicion arose as to the secret art by which they made their food more palatable than others could, and at a corroboree of all the animals their fire-stick was stolen, and so all the tribes came to possess the secret of fire.

This is the Australian version of the Great Flood.

There was no water. It had all been swallowed by a great frog. If he could be made to laugh he would have to disgorge it, so at a great corroboree all the animals did their best to amuse him. They failed until the eel began to dance. Then as he wriggled and writhed the frog could contain himself no longer. He burst out laughing, and out of his jaws rushed the waters and overspread the earth. Only islands stood up here and there above the flood, but the pelican steered a great canoe among them and took the survivors on board.

MODERN STONE-AGE KNIFE FROM CENTRAL AUSTRALIA

Most primitive peoples feel that men and animals are essentially similar, and in their folklore men, trees, and animals shade into one another, are changed into one another, or are sometimes one and sometimes the other in a fashion that is puzzling to civilized readers. Yet even in medieval Europe we have records of the trials of animals (usually in their absence) for murder or theft, followed sometimes by the sentence of excommunication by the Church; and, in *The Merchant of Venice*, Gratiano cries out against Shylock that there dwells in him the spirit of a wolf, "hanged for human slaughter." The stories in Ovid's *Metamorphoses* are no doubt late and literary renderings of primitive European folklore—tales told round their hearths perhaps by cave-dwellers Readers of the *Metamorphoses* will easily recognize a likeness in the tales to these from Australian folklore.

A SPEAR-HEAD CHIPPED AND FLAKED FROM A PIECE OF GREEN BOTTLE GLASS. WEST AUSTRALIA

Two old women killed a kangaroo. They hid it and told the hunters who asked what they were having for dinner that they had only mussels. But the child they had with them kept crying for kangaroo. So the hunters stole it, and refused to give even a little to the hungry child. Then the old women sang up a hailstorm which would have killed the men if they had not been turned into birds.

A widow and her children were struggling over the desert. Some tribesmen overtook them, and the woman besought their help. They could not stop, they said; they were going to a corroboree. But in the middle of the corroboree the woman appears. The children are dead of thirst. " Since you were in such haste to get here," she says, " stay here. Be trees."

And the other tribes she turned into crows, black swans, kangaroo rats, and other animals

The trees still stand round the place of the corroboree, proving that the story is true.

Primitive man exercises his imagination to account for the habits and peculiarities of animals, and the origin of the constellations. The Australian native tells us why the sun travels across the sky. She is a woman who went with her little son to dig yams. Somehow they became separated, and she wandered right round the edge of the earth seeking him till she came up the other side, and having formed a habit of travelling, she continued to do this.

The moon is a man. At new moon he is starving, so he goes on a fishing expedition and grows fatter, until he appears as full moon. Shooting stars are the souls of the dead; the Milky Way is a river full of fish. The Pleiades are a group of maidens making corroboree music for the young men who form Orion's Belt. Thunder is the voice of a god, as to the Greeks it was the voice of Zeus, or the noise of his chariot wheels rumbling over the heavens.

Goomblegubbon the bustard was jealous of Dinewan the emu on account of her wings. So she hid her own wings and said to the emu: "All the birds have wings. You, their queen, ought to be able to do without them. I have cut mine off. See that the birds do not make me their queen."

Dinewan the emu went and cut off her wings and then came back, but the bustard laughed and taunted her.

Dinewan said: "Why do you have twelve puny children? Look how big mine are; but then I have only two. If you kept only two children and gave them all the food they would grow into giants."

So Goomblegubbon the bustard killed all her children but two, and the emu laughed at her.

Since that time emus do not fly, and bustards have only two eggs each season.

Remote tribes of Eskimo have a great dread of all the tribes with which they have not come into direct contact, and always describe them as wicked and dreadful. Some of them, they say, have only one eye in the middle of their foreheads, and Odysseus, as we know from the *Odyssey*, came across such a people in the Cyclopes. Even as late as the fourteenth century the Englishman Sir John Mandeville brought home from his travels in Tartary, Persia, Armenia, Lybia, India, and elsewhere reports quite as strange.

When cave-man in Europe was driven by fever, flood, or famine to seek a new dwelling he set forth with his stone weapons in good order, followed by his wife and children, and keeping a sharp look-out for the animals which might furnish an evening meal, and those which he might have to fight for his life and theirs. It was necessary that he should be encumbered only with his weapons, his bow or his spear, his knives, and his clubs; all the little things that make a home his wife would carry, as well as any children who could not run by her side. This is a list given by Grey the traveller of the collection in a West Australian woman's bag, and we may imagine our cave-woman ancestress in these islands setting out with some such another: a flat stone to pound roots with, earth to mix with the pounded roots, quartz to make spears and knives, stones for hatchets, prepared cakes of gum for making and mending weapons, needles of kangaroo shin-bone, opossum hair for belts, mussel shell for hair-cutting, knives, axes, pipeclay, red ochre, yellow ochre, bark to carry water in, waist-bands and spare ornaments, pieces of quartz carried as amulets, *Banksia* cones or pieces of fungus for use as tinder or for carrying fire from place to place, grease, roots collected during the day, spare weapons which the husband does not wish to carry, skins in course of preparation for garments, and other articles.

Primitive peoples have many devices for getting fire. The following is the account given by Captain Cook of the method he found in use among the Australian natives.

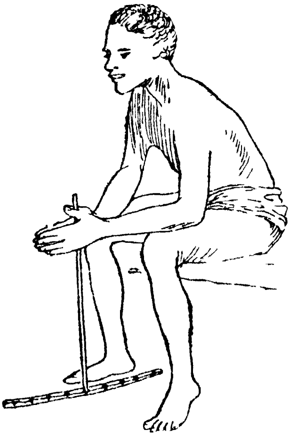
FIRE STICK

Another stick is twirled rapidly in one of the grooves

"To produce fire they take two pieces of soft, dry wood; one is a stick about eight or nine inches long, the other piece is flat; the stick they shape into an obtuse point at one end, and pressing it upon the other turn it nimbly by holding it between both their hands, as we do a chocolate mill, often shifting their hands up and then moving them down upon it to increase the pressure as much as possible. By this method they get fire in less than two minutes."

The European reader who tries to follow out these directions will take longer.

Prehistoric man in Europe was, as we have seen, no mean artist, and a similar skill in painting and drawing is found among the Australian natives, the Bushmen of South Africa, the natives of New Guinea, and the American Indians, those in the stage of Old Stone man excelling as he did in the life-like representation of animals, and sometimes depicting single human beings, or battle and hunting scenes, while those in the New Stone Age condition of culture appear usually not to have this power, and confine themselves to conventional decoration of pottery and weapons. Primitive man of to-day delights in the dance, for which he decorates himself with paint, feathers, fillets, and such necklaces and amulets as pleased the eyes of prehistoric man, who, though we can have no evidence of it, doubtless loved dancing too. For such dancing as primitive peoples engage in is both a social observance and an expression of emotions, a symbolical representation of the great events of life, or perhaps of the phases of nature. It contains the germ of the drama. It is a mode of self-expression, and self-expression is one of the first necessities of the human spirit.



AN AUSTRALIAN METHOD OF OBTAINING FIRE

A pointed stick is twirled rapidly in the groove

CHAPTER XV

THE USERS OF BRONZE

NEXT to the invention of fire-making the most important step in the material progress of mankind was the discovery of the art of metal-working. Where the discovery took place, or whether there were several centres of invention, we cannot be sure, nor can a general date be named when the use of metal superseded that of stone. In some remote parts of the world the use of stone weapons and tools went on for thousands of years after it had been abandoned in others; the date of the adoption of metal in place of stone was often separated by centuries even in the case of countries lying not far apart. Stone implements, moreover, continued to be used after the introduction of metal, and are constantly found in graves together with bronze. In the early days of metal-working the centres of manufacture would be few, and the implements and weapons of metal consequently scarce and costly. Those of stone would continue to be used for some time, partly from conservative feeling, but chiefly from necessity, though their general inferiority might be well recognized. And when the use of metals had quite superseded that of stone for ordinary purposes articles of stone would continue to be made for employment in religious ceremonies, and would be treasured as amulets, or charms against misfortune, because of a supposed holiness attaching to them on account of their connexion with those 'good old days' when the gods walked on earth, and men were braver and more beautiful, and the harvests more abundant—distance in time as well as space lending a glamour not possessed by what is near. Thus flint flakes and stone implements were placed in graves as a sign of religious feeling, and for this reason the custom was discouraged after the introduction of Christianity as a relic of paganism. It was encouraged, however, as a sign of abhorrence in the case of suicides, to whom Christian rites were forbidden. Thus in *Hamlet* the priest, speaking of Ophelia, says:

> Her death was doubtful;
> And, but that great command o'ersways the order,
> She should in ground unsanctified have lodg'd,
> Till the last trumpet; for charitable prayers,
> Shards, flints and pebbles should be thrown on her

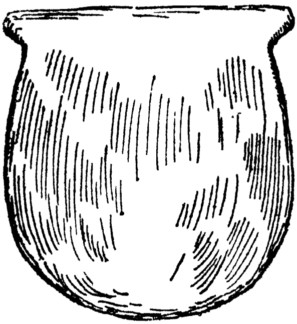
Thus a mode of prehistoric burial survived in tradition and was looked upon as befitting a person who had put himself outside the pale of the Christian Church. Where the knowledge of the former employment of flint implements has been lost flint arrow-heads and axes are often believed to be thunderbolts fallen from heaven, and are regarded with superstitious reverence.

Though the Age of Metals opened at such widely separated times in different parts of the world, and though, owing to the overlapping of different stages, no exact date can be assigned to it in any country, we may say that in Northern Europe it succeeded the Stone Age—which had lasted for an immense length of time, to be measured only by geological epochs—about two thousand years before the Christian era. The period from 2000 B.C. down to the beginning of recorded history is usually divided into two, according to the metal which was then most important to the human race—an Age of

Bronze and an Age of Iron. The Age of Bronze ended in Europe between 1000 and 500 B.C.

Bronze is, of course, not a simple metal, but an alloy consisting of copper combined with about 10 per cent. of tin. It is not probable that the making of such an alloy was prehistoric man's first essay in the working of metals. Some of the American Indian and Eskimo tribes learnt, unaided by the white man, to hammer out implements of copper, which often occurs in a comparatively pure state. Prehistoric man might easily have made the same discovery, but though copper implements made by him have been found, and appear to have preceded in many parts of the world those made of bronze, they have all been made by casting melted metal, a process which involves quite new methods and is not derived, as in the case of hammered copper, from the manufacture of flint. It is likely enough, however, that the invention arose from the chance melting of a piece of surface ore on the domestic hearth. Some reflective mind would be struck by the advantages of the new material, notably that many implements could be made from the same mould. Experience would show that they had one great drawback in comparison with those of stone. The metal was soft and its cutting edge soon dulled. Copper ore, however, often occurs in association with tin ore, and an alloy of the two metals accidentally made would be found to be greatly superior in hardness to the pure copper. The admixture of tin with copper would be repeated, and experiment would discover the proportion that made the best alloy. The invention would be transmitted from region to region. The peoples who had been using copper would abandon its use for that of bronze, while those who were still employing stone would pass at once to the use of bronze without any intermediate stage

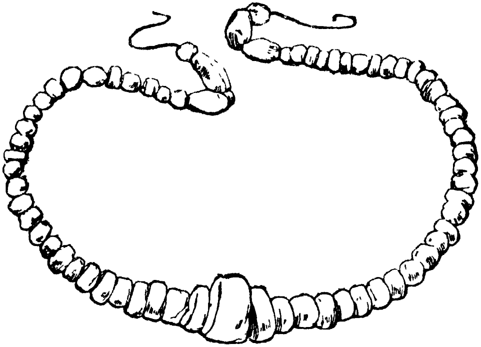
As regards the origin of the invention, it is almost certain that Egypt and Mesopotamia produced bronze some four thousand years before the Christian era, and as these countries have copper, but no tin, while copper and tin are found associated abundantly in Southern China, it is possible that it was from the Far East that the Near East derived its knowledge, and then transmitted it to the West.



COPPER AXE HEAD FROM EGYPT

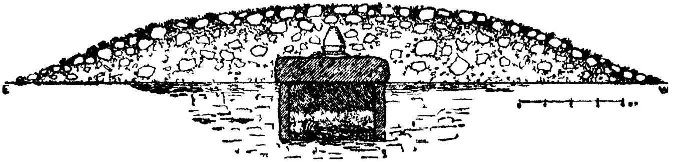
Many countries of Europe, however, have both tin and copper ores, so that the discovery may have been made in one of them and carried eastward—in which case it must have been made as early as 4000 B.C. It seems on the whole more likely that the invention was made independently in different countries and that the knowledge diffused from more than one centre.

A number of new wants would be created by the new metal industry, and the satisfying of these would lead to a great development of trade and intercourse. Countries which possessed supplies of tin and copper, and which had also a knowledge of metal-working, would export manufactured articles of bronze, and a traffic in the raw materials would be carried on between the sources of supply and centres unprovided with metals but acquainted with the nature of the alloy and skilled in fashioning it. The inhabitants of Cornwall were producing tin, and probably also copper at a very early date, for the Phœnicians of Tyre and Sidon were visiting this country to trade for it between 1500 and 1200 B.C. It is recorded that they carried on the tin trade from Cadiz, and it is possible that they founded this port as a half-way house between Cornwall and their own country They may have brought finished implements of bronze to barter for the ores, and it is possible that it was they who imparted the secret of the alloy, or themselves set up smelting centres in Britain and on the continent of Europe. At any rate, as they came in sea-going ships, the timbers of which would be fastened with copper bolts, they must have possessed some knowledge of the working of metals. Spain, besides forming a link between the Mediterranean and North-west Europe, would attract their notice owing to her wealth of silver, tin, and copper, and probably the oldest route of communication between the Near East and the West led by the islands of the Western Mediterranean through Spain, Portugal, and Western France to the British Isles and Northern Europe.



AMBER NECKLACE

Ireland was famous in the ancient world for gold, which she bartered for, among other things, amber from Jutland and from the east coast of England. The abundance of amber, in great request for ornaments, on the west coast of Denmark and on the south shores of the Baltic, brought into existence two great trade routes through Germany to the Mediterranean—one from the North Sea by the Elbe, Inn, and Adige to the head of the Adriatic near Venice, the other from Dantzig by the Vistula, Oder, and March to the Danube, and thence to the Gulf of Trieste.

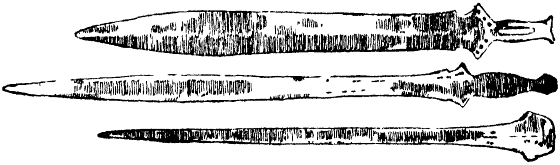


SECTION OF ROUND BARROW

The Rhône valley formed part of another highway of trade between the Mediterranean countries and North-west Europe

Countries adjacent to these and other trade routes would be the first to become acquainted with the working of bronze, and later on of iron. Such regions as Scandinavia, then the end of the known world, and Eastern Hungary, lying east of the great amber route from the Baltic to the Adriatic, would be the latest to hear of new inventions and to adopt new ways of life, and as these countries were late in entering upon their Bronze Age they were even more markedly slow to adopt iron in place of bronze, with the result that their bronze remains are unmatched for variety and beauty of workmanship in the more progressive regions that passed quickly to the use of iron.

It has been said that the Age of Stone overlapped that of Bronze, and that then it was only gradually that the use of metal superseded that of stone. Yet, though there is no reason to believe that the art of metal-working was introduced into this country by a conquering race, we have evidence that a population different from the users of polished stone was settled here during the Age of Bronze.

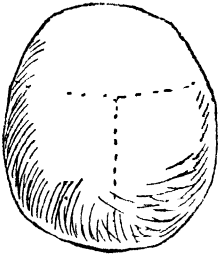


BRONZE SWORDS

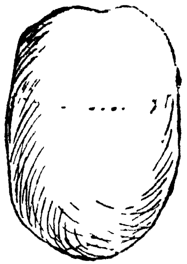
In the first place, they constructed their graves after a different pattern. The barrows of the later Stone Age are very long in comparison with their breadth; the length runs east and west, and the east end is broader and higher than the other.

The barrows of the Bronze Age, on the other hand, are circular and more or less conical; moreover, they contain human remains of a type not found in the long barrows. In long barrows we find the skeletons of long-headed men, in the round barrows we find long-headed men and also men of a new type, with round, or rather short skulls. It should be explained that a skull is called long if its width is not more than 75 per cent. of the length, and short if the width exceeds 80 per cent. The difference in proportion of the skull is only one, however, of many divergences between the two types. For example, the long-headed men appear to have had an average height of 5 feet 5½ inches. The average of the short-headed men was three inches more than this, and they were stronger in proportion. They suggest a race of successful invaders, and the presence of many skulls of intermediate proportions in the round barrows seems to indicate that they intermarried with the earlier inhabitants of the country and produced a race of mixed type.

The earliest inhabitants of these islands whose name has come down to us were the Picts, who were probably the people whom Cæsar mentions as claiming descent from the first inhabitants. They would appear to be the long-headed people of the long barrows. Spreading from some centre probably in South-east Europe came wave after wave of migration, bringing hordes of fair-haired, short-headed invaders upon the earlier inhabitants of the Mediterranean peninsulas, Germany, France, and Britain. An intermixture of races took place and the migrations continued. In Britain the new-comers were a Keltic-speaking race, the Gaels, probably from the nearest parts of the Continent. They drove the Picts into the northern part of the island, from which in later times they made incursions into Romanized Britain, but with the remnant of the Pictish race in the southern part they seem to have inter-

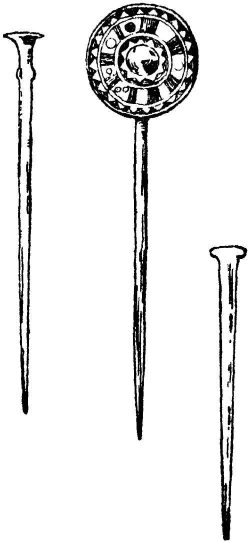


BROAD OR BRACHYCEPHALIC SKULL. TOP VIEW



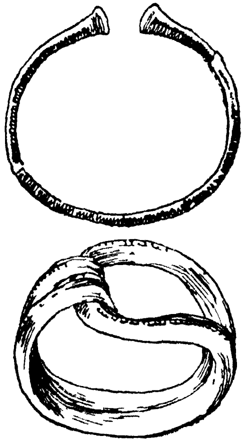
LONG OR DOLICHOCEPHALIC SKULL TOP VIEW

mingled freely, producing the race of mixed type whose remains are found in the round barrows. The Gaels had occupied most of the country south of the Firths of Forth and Clyde when a fresh wave of migration brought into Britain the Brythons, a race speaking a dialect of the Keltic tongue. These invaders drove them north and west into the highlands of Scotland Ireland, and the Isle of Man, gave their own name to the island, and later on were themselves pressed northward by the settlement in South-eastern Britain of yet another Keltic-speaking stock the Belgæ, who have given their name to modern Belgium It is probable that at least two of these population changes had taken place before the close of the Bronze Age in Britain.



Bronze Pins

The relics of this age that we possess prove that with the discovery of the art of metal-working a number of new wants arose and were satisfied by the ingenuity of man. Human life was losing its first bare simplicity as men advanced from the hunting stage of existence to the beginnings of agriculture and settled life. The thick forests in Europe and the British Isles, through the tangled foot-paths of which hunters tracked the wild beasts which were their food, gradually became dotted with settlements trading in a primitive way with one another. We cannot say much about the actual dwellings of the people except that they must have begun to build larger and better log-houses, and that the chiefs probably fortified theirs with moats, earthworks, and wooden stockades It is likely that many promontory and ring forts date back to the Bronze Age. The lake-dwellings, if not of the Bronze Age, were certainly occupied during it. Rock-carvings in Norway and Sweden show not only that the soil was cultivated, but that the horse was used for riding and driving, large ships for rowing were built, and picture-writing existed. Garments were mostly woven of wool and adorned with fringes of different colours. Many such have been found in Jutland in graves containing cists, or coffins, of hollowed oak. The men wore jackets and caps, carried swords sheathed in wood or leather by a leather strap over the shoulder, and, as we see from the number of bronze razors found, were in the habit of shaving. The women wore hair-nets, jackets, and long skirts. The poorer classes probably were clad in garments of skins. Ornaments were made of jet, bronze, and gold, and sometimes inlaid with resin and amber. Weapons were elaborate and splendid, and so abundant was gold in some centres that heavy ornaments of this metal were worn not only by chieftains but by their horses. Distinctions of rank had already put so much difference between a ruling warrior and a skin-clad man of the people.


GOLD BRACELETS

CHAPTER XVI

THE IRON AGE

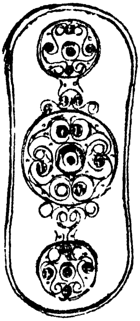
TO the last of the prehistoric stages in the progress of man we give the name of the Early Iron Age. With the first bar of iron smelted a new era had begun. Immense advance, it is true, in the arts of life had been made during the transition from rude tools and weapons of unpolished stone to those, beautiful and elaborately wrought, of the Bronze Age. Yet man had to discover iron before he could go far in the conquest of his environment, and once discovered, so indispensable did iron prove that the civilized world is still in the Iron Age. Next to air and water there is probably no one material that we could not better do without. It is the most abundant of the heavy metals—iron-bearing stone is a main constituent of the hills themselves—it is the strongest, the most magnetic, the most varied in its properties. It can be made extremely hard by sudden cooling, or soft and pliable by slow cooling. It supplies the irreplaceable steel of our cutting tools, and magnetic iron is the basis of commercial electricity.

So great was the advantage conferred by the possession of tools and weapons of the new metal that for long after its discovery a superstitious reverence was felt by ordinary men for the smiths who understood the working of it. Northern folklore made the first iron-smith, the forger of magic swords—Wayland Smith, as the English called him—half divine, just as the Greeks and Romans placed the metal-worker, Hephæstus or

Vulcan, among the gods. Yet in spite of the overwhelming merits of iron—or perhaps because of the mystery that seemed to attach to the workers—the new metal was looked at askance in some regions as something strange and uncanny. Some countries continued using the more beautiful bronze long after iron must have been known to them, and even when iron was in use for all everyday purposes bronze was retained for ornament, and for religious and ceremonial use. As when stone was supplanted by bronze, the metal that had passed out of common use acquired a sanctity from its association with ancient days.

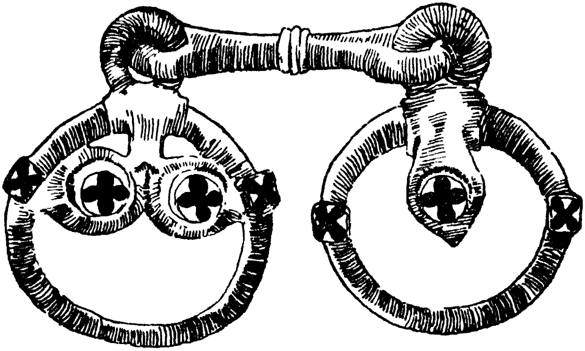
The earliest objects made of iron imitated the forms of bronze, though the latter, being adapted to cast metal, were often unsuitable for manufacture in iron, which for a long period was always wrought, never cast. Iron articles which are most like bronze and therefore nearest to the Bronze Age stage of progress are found chiefly in the interior of India, which was perhaps the centre from which a knowledge of iron radiated in various directions. Assyria, Judea, and other regions of Asia had it long before Europe, and inscriptions prove that iron was in use in Egypt more than two thousand years before the birth of Christ. From Egypt it spread south and west into the interior of Africa, which passed from her Stone Age to the Age of Iron without an intermediate Age of Bronze. At last it reached the south of Europe, and trade routes carried it from Macedonia and the Greek colonies of the Black Sea and Marseilles to South Russia, Hungary, Gaul, and the British Isles. It was this trade intercourse that about 200 B.C. introduced a coinage into South-eastern Britain which imitated that of Philip II of Macedon. It is possible, however, that the Britons, who during the Bronze Age were accustomed to the use of the furnace in the extraction of tin and copper from the ore, discovered the art of iron-working for themselves. We have at any rate proof that iron was produced in Britain centuries before the Roman occupation.

Many myths arose to relate how it was discovered, but the most general belief was that lumps of iron fit for hammer and forge had been found after a great forest fire. The Homeric poems represent Greece as entering her Iron Age about twelve hundred years before the Christian era, and when they were written the art of tempering steel was so well understood that the poet compares the hissing of the stake with which Ulysses put out Polyphemus' eye to that of steel plunged into water, adding an allusion to the strengthening effect of this cooling on the steel. The notable warriors in the Trojan War had swords of bronze, while the common soldier's was of iron, the greater beauty of bronze probably causing it to remain the aristocratic metal.

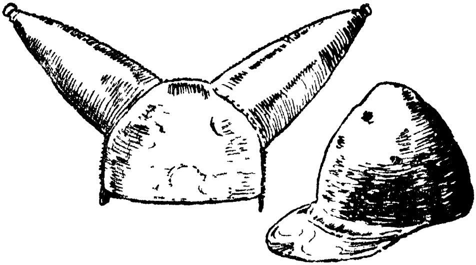

ENAMELLED BRONZE SHIELD

We do not yet know the exact form of the earliest furnace. Comparison with the primitive iron-making still carried on in India, Burma, China, and Japan makes it likely that the ore was mixed with charcoal in a shallow hole in the ground, and a blast applied over the edge to obtain the necessary high temperature. Fine qualities of iron and steel can be thus produced. Later on a hollow for the furnace was scooped out in a bank facing the prevailing wind, a hole being made for the removal of the iron, and the blast introduced at the bottom of the furnace either through the same hole or another. For blast the primitive smith would use his own breath or a fan, device after device improving on the preceding ones until at last the first crude bellows were evolved. The iron was never reduced to a liquid state, but obtained from the ore as a solid mass of malleable metal and hammered into shape.

That the population of Britain had undergone another change is shown by skulls from Iron Age burials. These bear witness that it was now predominantly long-headed, as it had been in the New Stone Age, the explanation perhaps being that the round-headed people of the round barrows had been absorbed in the course of the Bronze Age by the more numerous people they had subdued. The Druidical system which Cæsar describes prevailed, all power being in the hands of the Druids, who formed a priestly caste, and of the nobility, a warrior aristocracy. A Bronze Age warrior must have been a splendid sight with his weapons and armour of bronze and gold. These, however, though they added to the lustre of his appearance, did not increase his fighting value as did the war panoply of a knight


BRONZE AND ENAMEL BRIDLE BIT

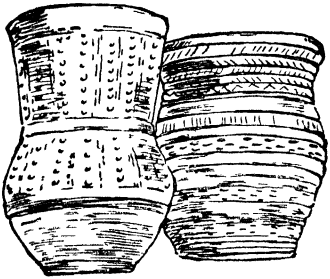
of the Early Iron Age. The common man who had no voice in the government no doubt had to follow his lord to the war he had not helped to make, and, clad in skins and rudely armed, to enter the battle only to be hewn down or to run away. But his lord, mailed, helmeted, crested, driving his chariot across the field, or mounted on an armoured and iron-shod horse, was a formidable fighting man, with some knowledge of the science of war, and practised in the attack and defence of towns. A warlike expedition in the Bronze Age was probably in many cases little but a splendid parade, ending in a few single combats and small general bloodshed. The Iron Age produced weapons that were not only much more effective than those of bronze, but so much cheaper that far larger levies could be armed and led into battle. Thus war, the sport of princes, was becoming more costly to the people.



BRONZE HELMETS

"*Dawn of British History,*" *Corkran* (*Harrap*)

During the time that fighting-chariots were used a warrior was often buried with his chariot. His body, sometimes wrapped in skins or woven stuff, resting on his shield, or with the shield on his breast, was laid between the two wheels of the chariot, these in one case standing in two trenches cut below the general level of the grave. The bits and trappings of the horses were placed in a trench at the foot, connected with it by a narrow channel containing the chariot pole. The dead man's weapons were laid beside his body and sepulchral vessels placed near. Bones of pigs, sheep, and oxen show that a funeral feast was usually held at the tomb.



DRINKING-CUPS

From the pottery preserved in tombs we find that the dots, straight lines, and cross-hatchings of the Bronze Age had given place to quite a different decoration of curved lines and flowing designs. The ware, too, was in general of much finer quality, and most of it was made on the wheel. Funeral urns were often covered with a lustrous black.

Ornaments were more varied and numerous. Among the many found in tombs are diadems, necklaces, bracelets, anklets, earrings, rings, and brooches, of gold, bronze, or iron, sometimes decorated with coral or different-coloured enamels. Glass, amber, and coral were used for beads.

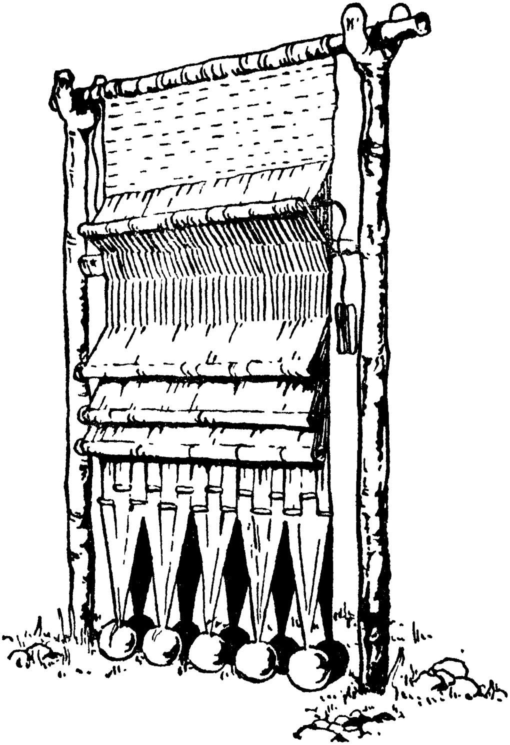
That trade received a great impetus from the discovery of iron is shown by Strabo, who wrote at the beginning of the first century A.D. He mentions wheat, gold, silver, iron, cattle, skins, slaves, and dogs as being exported from Britain in his day, while among the imports were bracelets and necklaces of ivory, amber beads, and glass vessels. The tin trade, which had once been so important, seems to have waned by this time. Bars of iron were used as a medium of exchange, and though coinage was introduced into the south-east of Britain about 200 B.C., the more primitive currency was still used in the interior in Cæsar's time.

With iron tools the art of building with stone arose, but except where stone was more plentiful than timber, timber and mud huts would continue to be the homes of the people. A lake-village of the Iron Age excavated at Glastonbury tells us much of daily life in the west of Britain before Roman influence penetrated there.

The village included sixty or seventy dwellings, and was occupied long enough for five feet of peat to accumulate in some parts. The huts were mostly circular and 18 to 35 feet in diameter, built of wattle and daub on a framework of posts a foot apart. These, with a centre post, supported a thatched roof. The clay floor rested on a layer of timbers laid close together on brushwood covering the lake bottom, as in the Swiss lake-dwellings. Among the relics from the site are a wheel, made on the lathe, a ladder, a dug-out canoe 18 feet long, and part of a loom; pottery made both by hand and on the wheel, stone querns, and a bronze mirror, found with antimony for darkening the eyebrows and eyelashes, and rouge. Crucibles show that the inhabitants smelted metals on the spot. They grew wheat, and had sheep, long-horned cattle, pigs, horses, and dogs as domestic animals, and they also hunted the beaver, otter, roe-deer, and stag.

Enamelling both on bronze and iron was an art that arose in the Early Iron Age, and nowhere was it practised with greater success than in Britain, where the craftsmen evolved processes peculiar apparently to themselves. The distinguishing feature of the age, however, was the introduction of the characters of the alphabet.

This enabled a written language to be developed, and it is believed that even in Britain the natives were acquainted with writing before Cæsar's invasion. With the establishment of a written language the foundations of literature and history were laid. Prehistoric times were past.

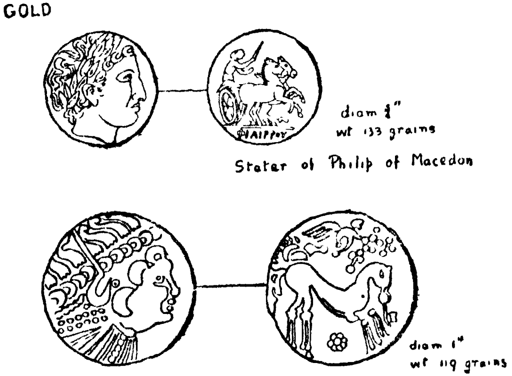


LOOM OF LAKE-DWELLERS

From "The Threshold of History," Hall (Harrap)

The Iron Age, however, went on, and it may be as well to say a few words about the development of that iron-working upon which a great part of our daily life to-day depends.

The small furnaces of the early iron-workers, seldom exceeding 10 to 15 feet in depth, were wasteful of fuel, labour, and iron. The cinder-heaps left in the Forest of Dean from the iron-working of the Roman occupation contained so much iron that they supplied ore to twenty furnaces for some hundreds of years. Charcoal was the only fuel used in England for smelting till the seventeenth century. This, obtained from the surrounding forest, was used to reduce local ore to wrought iron. Many landowners had their own forge and smithy to supply them with iron tools for use on their estates. As the charcoal would turn some of the iron into natural steel, which is brittle, the smith would be under the necessity of remelting it and converting it into malleable wrought iron, and this process, which arose from accident, was found to have advantages which led to its



THE GOLD STATER OF PHILIP OF MACEDON AND A BRITISH IMITATION being adopted deliberately. By the sixteenth century the demands of the iron industry were thinning the forests to such an extent that an Act of Queen Elizabeth prohibited the cutting of timber for that purpose in some districts, and a later one of the same reign forbade the construction of new ironworks in Kent, Surrey, and Sussex. In 1611 Simon Sturtevant patented a method for using mineral coal in place of charcoal, and he was followed in 1619 by Dud Dudley, who advocated the same change ; but the innovation met with so much opposition from the ironmasters that it failed to establish itself. Coal was reintroduced in the iron industry in 1713 at Coalbrookdale, but the methods it entailed were not thoroughly understood, and production decreased until, about the middle of the eighteenth century, the manufacture of cast iron with coke in the high furnace was invented. The substitution of coke for charcoal, and the invention of machinery, such as Watt's steam-engine, which required coal as fuel, were partly the cause of that migration of industry to the towns of the great coalfields which marked the beginning of the Industrial Revolution. Nowadays the furnace scooped by prehistoric iron-workers in the ground or in a bank has been succeeded by the modern blast furnace, a hollow tower from 40 to 100 feet in height, and with a capacity of from 500 to 25,000 cubic feet.

It is possible that the use to any considerable extent of coal, on which the modern development of the iron industry depended, first began in Britain. It was at any rate in household use in Anglo-Saxon times, as early as the ninth century A.D. About the end of the thirteenth century it began to be employed in manufacture in London, but its use was unpopular, as it was supposed to be injurious to health. In 1306 its use was actually prohibited, but in spite of this it was soon the general fuel in London owing to the high price of wood. With the invention of the steam-engine it became the main source of power.

It was believed at one time that our coal supplies were inexhaustible. This is by no means the case, and it is a question of the present day to what extent it is prudent to convert them into electric power rather than to consume them wastefully as fuel. The replacement to a great extent of steam power by electricity is likely in the near future to bring about great changes in our daily life. At present electric power is dependent on magnetic iron, and, in this country, on the energy stored in coal; but it may not be long before the coal era is brought to an end, because science has grasped the means of utilizing directly the energy of sun, wind, and tide, and of releasing the energy of the atom.

CHAPTER XVII

MAN DISCOVERS THE UNIVERSE

SOME time between 1000 and 500 B.C. all over Europe the substitution of iron for bronze as the metal of everyday use had ushered in the last division of prehistoric time. When the characters of the different alphabets were devised written language began, and man passed from the darkness of immense prehistoric ages, upon which only a little light is shed by relics found in rocks, caves, and tombs, into the dawn of history. Written history in Europe goes back, then, between two and three thousand years; it is believed that man has existed in Europe at least a hundred and fifty thousand years. What master-minds led him in his progress from a mere struggle for existence with teeth and hands, sticks and stones, a struggle during which he had to pit his cunning against the strength and fleetness of wild beasts, and to compete with them for the possession of a wild beast's lair, to the use of fire, the building of houses, and the fashioning of implements of stone and metal, we shall never know. These unknown thinkers were the eyes of a humanity groping in darkness. Through their vision existence, when history opens, had lost half its material terrors. Life was no longer for all men a struggle that began afresh every day. It had become possible for some to give themselves to a life of thought. Curiosity was born as the human spirit awoke. There was plenty for it to work on. Man had to discover the universe;

he had to discover the earth; he had to discover himself.

The beginnings of trade would make north and south, east and west, acquainted with one another through strange tales of different customs, climates, beasts, and men,

> The Anthropophagi, and men whose heads
> Do grow beneath their shoulders

Primitive religion and primitive art would spring from man's curiosity about himself, his desire to know why he is here and where he is going, and to transmit to others his impressions of life.

Perhaps as early as the mind of man was capable of thought at all the mere succession of days and nights must have set him wondering about the sun and moon and stars, and devising explanations to satisfy his own and others' questioning.

Earliest history shows us communities of men already possessed of elaborate religious systems and beautiful forms of art, with extensive trade relations, and with theories of the universe which were something more than "a wild surmise." It is one of the greatest wonders in the record of the human race that even while men had but a scanty knowledge of the earth on which they were placed there were some whose minds were already set upon obtaining an answer to the riddles of the universe.

Probably the earliest star-gazers were Egyptian priests, evidence of whose astronomical knowledge exists in the construction of the pyramids, which were built several thousand years B.C. Indian and Chinese records refer to observations made between two and three thousand years B.C.; and not much later Chaldean priests in Babylon were not only acquiring real astronomical knowledge, but laying the foundations of that false science called astrology which, professing to predict wars, pestilences, and famines by observation of the heavens, to interpret a man's fate by the position of the stars at his birth, and to choose a favourable date for the beginning of an enterprise, has held such a fascination for the human mind that belief in it, as witnessed for instance by *Old Moore's Almanack*, is not quite extinct even at the present day. Based as it was upon credulity and superstition, astrology, like other false sciences, stimulated a desire for true knowledge, and so was not without its uses.

While wishing to give all due credit to these ancient astronomers, we know little really about the extent of their knowledge, except that they seem to have devoted themselves to making observations rather than to seeking for causes. The first really historical astronomers were the Greeks, who may have derived their astronomical skill from the Chaldeans, the Egyptians, or from men of their own race. But before history opens it is probable that a rough attempt had been made to divide the stars into the groups we call constellations, and to name them, as well as some individual stars. Five bodies—Mercury, Venus, Mars, Jupiter, and Saturn—which like the sun and moon underwent change of position were called planets, or wanderers, to distinguish them from the so-called fixed stars. One of the first purposes to which astronomy was applied was the measurement of time. The appearance and disappearance of the sun, bringing heat and light, or leaving darkness behind it, is the most obvious of astronomical facts, and thus the day is the simplest unit of time. The next most obvious unit is the lunar month—that is, the period during which the moon goes through her phases. The sun is daily seen to rise in the east, to travel across the sky, and to set in the west. But the points of the horizon at which it rises and sets, its height in the sky at midday, and the duration of daylight, all go through a series of changes which are accompanied by changes in weather and vegetation which we call the seasons, and which recur after a certain period of time. Thus we have a third unit of time, the year. Both Chaldeans and Egyptians seem to have known that the year consisted of about 365¼ days, and one of the functions of Greek astronomers was the proper regulation of the calendar.

The Greek calendar was based on the moon, and at an early period the year was made to consist of twelve months of thirty days. By the fifth century B.C. various adjustments had reduced the length of the year to 365¼ days, but a preference for beginning the month when the new moon was first visible caused arbitrary alterations and much confusion.

In early times the Roman calendar was even more confused than the Greek. It was known to be inaccurate, and so the priests were supposed to correct it from time to time to make it agree with the sun and moon. They, however, allowed it to fall into such chaos that the first day of each month had to be proclaimed by crier. A reformed calendar was produced by Julius Cæsar under the advice of an astronomer of Alexandria named Sosigenes. The year was calculated independently of the moon, an ordinary year consisting of 365 days, and every fourth, by the addition of a day to February, of 366, so that the average length of the year would be 365¼ days.

The Julian Calendar, which began in the year 45 B.C., and is still in use over the civilized world, has undergone only one reform of any importance. The difference between the average length of the year as fixed by Julius Cæsar and the true year amounts to about one day in 128 years. In 1582 Pope Gregory XIII arranged that ten days should be omitted from that year and three leap years in each four centuries. The Gregorian Calendar was not adopted in England till 1752, when 11 days had to be omitted, and it has not yet been adopted in Russia and Greece.

The history of Greek astronomy extends over eight centuries, from the sixth century B.C to the second A.D. The Greeks, unlike their Eastern predecessors, were much more interested in framing theories of the universe than in making observations, a considerable number of which they had, moreover, inherited. These theories were at first mainly fanciful, but later Greek astronomers followed a truly scientific method. They framed a provisional theory to account for facts observed, deduced the mathematical consequences, and tested the truth of the theory by comparing these consequences with the actual facts. Many such theories appeared, of course, to stand the test of facts and afterward were proved false. That is no argument against what is called the inductive method, but merely proves that insufficient facts have been available.

Of the early Greek astronomers the best known is Pythagoras, who lived in the sixth century B.C., chiefly famous for his doctrine of the transmigration of souls. He taught that the earth, in common with the heavenly bodies, was a sphere, resting without support in the middle of the universe. The stars, he held, were attached to a crystal sphere which revolved daily on an axis through the earth, and each of the seven planets (including the sun and moon) moved on a sphere of its own, producing a music audible to the finest ears.

This doctrine of the music of the spheres affected the imaginations of men, and Shakespeare has alluded to it in *The Merchant of Venice*:

> There's not the smallest orb which thou behold'st,
> But in his motion like an angel sings,
> Still quiring to the young-ey'd cherubins.

One of the followers of Pythagoras who lived about a century later than his master grasped for the first time the idea that the earth was in motion. He appears to have regarded it as revolving, together with the sun, moon, and five planets, round some central fire, the earth rotating on its axis as it revolved. It is clear that several other Pythagoreans also believed in the rotation of the earth.

The great philosopher Plato makes several references to astronomy in his writings. In the *Republic* he describes the sun, moon, planets, and fixed stars as revolving on eight concentric spheres round an axis passing through the earth. He also states that the moon shines by reflected light received from the sun. One of his disciples, Eudoxus of Cnidus, went further in a similar attempt to explain the motions of the heavenly bodies. He is the first Greek recorded to have had an observatory, and he produced the first systematic description of the constellations.

Aristotle (384–322 B.C.) in his astronomical writings set forth the best knowledge of his day, but did not contribute anything original of great importance. He discussed and rejected the possibility of the earth's revolving round the sun. He was far from regarding the knowledge that he possessed as final, but so great was his authority that his works actually retarded the advance of astronomy because, even as late as the

Renaissance, his name was invoked by unintelligent disciples to defend theories which later research had shown to be unworkable.

After the time of Aristotle Alexandria, founded in 332 B.C. by Alexander the Great, who was for a time a pupil of Aristotle's, became the centre of Greek learning. During five centuries all the astronomers and mathematicians of importance, with one great exception, belonged to Alexandria, where the Ptolemies, whose capital it was, had founded the great museum, containing an observatory and a splendid library. To summarize briefly the achievements — the results of

AN ASTRONOMER

From "In Feudal Times," Tappan (Harrap) lifetimes of toil—of the early Alexandrian school, the best-known member of which is Euclid, they investigated the comparative distances of the sun and moon from the earth ; discovered that the diameter of the moon was about one-third that of the earth (a result very near that obtained by modern scientists) ; discovered also that the fixed stars were immeasurably distant as compared with the sun ; made the first real star catalogues ; constructed improved sundials (first made in Babylon) ; divided the earth into zones according to the seasons ; and made scientific and successful estimates of the circumference of the earth.

Ranking far above these discoverers, however, and among the greatest astronomers of all time, was Hipparchus, who lived in the second century B.C., and who was not, as far as we know, a member of the Alexandrian school. He invented trigonometry, a branch of mathematics of great service in astronomy, made a valuable series of observations, taken with all the care that his instruments permitted, and compared old observations with later ones so as to discover astronomical changes too slow to be apparent within a single lifetime. He improved the theories of the motions of the sun and moon, invented a new geometric representation of their motions, and was thus enabled to predict much more successfully than his predecessors eclipses of the sun and moon. Though superstitious terror was long caused by eclipses, it was known by Greek astronomers at least as early as Aristotle (in the fourth century B.C.) that eclipses of the moon were caused by the passage of the earth between the sun and moon, and eclipses of the sun by the passage of the moon between the sun and the observer. From the time of Hipparchus eclipses of the moon could be predicted by any astronomer to within an hour or so, eclipses of the sun probably with less accuracy.

For nearly three centuries after the death of Hipparchus there is no great advance in astronomy to record. The last great Greek astronomer was Ptolemy, who lived in Alexandria about the middle of the second century A.D. He produced a great astronomical treatise, known as the *Almagest*, from the name given it by its Arab translators, which is mainly based on the work of Hipparchus, for whom Ptolemy continually expresses the greatest respect. Ptolemy himself was a distinguished mathematician rather than an original astronomer, but he worked out an improved theory of the motions of the planets, and throughout the Middle Ages his authority was regarded as almost final, except where the views expressed in the *Almagest* conflicted with those of Aristotle. After the death of Ptolemy the Alexandrian school fell into decay, and its end came in A.D. 640, when Alexandria was captured by the Arabs.

Thirteen centuries elapsed after the publication of the *Almagest* before the birth of the astronomer who was destined to reconstruct the traditional astronomy on a new basis. In the meantime little improvement was made in theory, though considerable progress was made in mathematics and in the art of observation. The most interesting event in the history of astronomy during this period was the development of the science in the East. The first translation of the *Almagest* was made at Bagdad, the capital of the Arab caliphs, in the eighth century A.D., by order of Haroun al Raschid, the hero of *The Arabian Nights*, and observatories were erected at Bagdad, Damascus, Meraga, in modern Persia, and Samarcand, in the present Russian Turkestan.

England produced in the thirteenth century two astronomers in the persons of the famous Roger Bacon and a Yorkshireman named John Halifax, who was for some time a teacher of mathematics at Paris.

Nicolas Copernicus, whose new system overthrew the Ptolemaic system of the universe, was a son of the Renaissance. He was born in 1473 at Thorn, on the Vistula, and his father was a Polish merchant. He was at school at Thorn, entered the University of Cracow, and then went to Italy, where he stayed for nine or ten years, ostensibly studying law and medicine, but giving most of his attention to mathematics and astronomy. On leaving Italy he went to live with an uncle who was Bishop of Ermland at Heilsberg, where he probably wrote the first draft of the book containing his new ideas on astronomy. In 1512, on the death of his uncle, he settled at the cathedral city of Frauenburg, where he had a canonry, and there he remained for thirty-one years, conducting some of the business of the chapter, and giving medical advice to his friends and to the poor, but devoting most of his time to astronomy. Before he had published anything of importance it became known that he considered the earth to be in motion, and the sun and stars at rest. This doctrine caused a stir in religious as well as in astronomical circles, and it was opposed by the reformers Luther and Melanchthon, while Copernicus himself was ridiculed on the stage. It was not till he was an old man that he decided to publish his great work. It was seen through the press by a Lutheran preacher interested in astronomy, who became alarmed by what he considered the heretical ideas of Copernicus, and who accordingly added a preface declaring untruly that the fundamental principles laid down in the book were merely abstract theories convenient for purposes of calculation. Copernicus received a copy of the book on the day of his death, 24th May, 1543.

The main idea of the *De Revolutionibus* is that the apparent motions of the heavenly bodies are to a great extent not real motions, but are due to the motion of the earth, carrying the observer with it. Similar views had been put forward without evidence by some of the followers of Pythagoras, but had been rejected by Aristotle and by Ptolemy, whose chief objections to them are discussed by Copernicus. He was successful in showing that a daily rotation of the earth about an axis passing through the poles, combined with an annual revolution about the sun, explained the observed motions of the celestial bodies better than the Ptolemaic system. Owing to the preface. and to the fact that the book was unintelligible except to readers of considerable mathematical knowledge, it was received quietly, and in fact its theories could not be generally accepted or, indeed, proved, until further mechanical knowledge overcame the difficulty of believing that the earth could be in rapid motion which was quite imperceptible to its inhabitants. Moreover, the comparatively few observations available, as well as the inaccuracy due to imperfect instruments, made it impossible either to develop them, or to test them properly, by comparing the results of calculation with those of observation. The latter half of the sixteenth century fortunately provided a mass of observations for the use of the next generation, and great progress was also made in mathematics. Our present notation, ascribed to the Arabs, in which the value of a number is altered by its position, thus avoiding the necessity of fresh symbols, had long been in use, and two other great devices for lessening the labour of numerical calculations—decimal fractions and logarithms—were familiar early in the seventeenth century.

The man whose labours did more than those of anyone else to provide the materials necessary for further developments of astronomical study was Tycho Brahe, a Danish nobleman born in 1546 at Knudstrup, in what is now the southern extremity of Sweden. Tycho studied mathematics and astronomy at the Universities of Copenhagen and Leipzig, travelled, and made the acquaintance of most of the German astronomers of note. He had a feeling that it was beneath the dignity of a nobleman to write books, but his friends prevailed on him to publish his first work in 1573, and in 1576 Frederick II of Denmark gave him the little island of Hveen in the Sound for his occupation, promised him money for a house and observatory, and assigned him the rents of the island as well as an annual payment of £100. Here Tycho built magnificent buildings, the chief of which, called the Castle of Heaven, contained, besides living-rooms, several observatories, a library, and a laboratory—for he paid some attention to medicine and to alchemy, the great-grandmother of chemistry, as well as to astronomy. He afterward set up workshops for his instruments, a printing-press, and a paper-mill. Here he lived in splendid style, oppressed his tenants, and produced a magnificent series of observations, far exceeding in accuracy and number anything achieved by his predecessors. Copernicus, for example, used only a few dozen observations in the whole of his great work *De Revolutionibus.* Tycho took thousands of observations of the sun alone. His own system of the world, published in 1577, was a compromise between the Ptolemaic and Copernican systems. He held that the earth was at rest, that the planets revolved round the sun, the sun performed an annual revolution round the earth, and the stars a daily one.

The Ptolemaic system was finally overthrown by the life-work of Galileo Galilei, who was born in 1564, the year of Shakespeare's birth, at Pisa. In 1581 he was sent to study medicine at the University, where he gained the nickname of 'the Wrangler' from his fellow-students because of his love of argument and unwillingness to accept statements based only on the authority of great writers of the past. Overhearing by chance a lesson on Euclid, he was so much interested that in his second year he gave up medicine for mathematics. However, poverty compelled him in 1585 to leave the University without taking a degree, though he continued to study at home. In 1589 he was appointed professor of mathematics, including astronomy, at Pisa, receiving a stipend of about five shillings a week, and it was here that he began his discoveries in mechanics by experimenting with falling bodies, some of them being dropped from the leaning tower of Pisa. In 1592 he was appointed to a better-paid post at Padua, where he wrote tracts on astronomy, mechanics, and fortification, and invented many scientific instruments. Having heard of the lately invented telescope, he made himself instruments that magnified thirtyfold, and with these he discovered that the moon was not, as commonly supposed, a smooth sphere, but mountainous, that Venus was, like the earth, a dark body deriving her light from the sun, and that Jupiter had four satellites revolving round him. He also discovered dark spots in the sun, these having been believed before to be caused by the passage across it of a planet. These discoveries all helped to overthrow the old beliefs that the earth was the only centre of motion, and that the celestial bodies were perfect, unchangeable, and of different composition from the earth.

It was about this time that the dispute arose whether observation and reasoning or the authority of the Church and the Bible, as interpreted by the Church, ought to have more weight in scientific matters, and the enemies of Galileo, who was known to have slight respect for tradition and authority, tried to draw him into a dispute with the Church. In 1615 the Inquisition declared it heresy to hold either of the doctrines that the sun was the centre of the world and immovable, or that the earth was not the centre of the world and in motion. As a result of this adverse report upon the Copernican theory the Pope ordered Galileo to be summoned and censured. In 1632 Galileo published his great treatise, the *Dialogue on the Two Chief Systems of the World, the Ptolemaic and the Copernican.* The dialogue form enabled him to present the Copernican case as strongly as he could through the mouth of one of the speakers without identifying himself with the opinions expressed, and he hoped that this would save him from appearing to defy the Inquisition. But as the advocate of the Copernican system always confutes the upholder of the Ptolemaic and promptly convinces the third speaker, who is neutral, it was easy to see on which side Galileo's sympathies lay. In fact the book was an unanswerable argument for Copernicanism. It aroused great opposition, and unfortunately the Pope believed that he was himself the original of the supporter of Ptolemy's views in the *Dialogue*, this speaker being continually held up to ridicule. Galileo was brought before the Inquisition three times, examined under threat of torture, compelled to abjure his errors, and condemned to imprisonment and penance. The imprisonment was of a very mild description, however, and at the end of a year Galileo was allowed to retire to his country house near Florence, where he continued his work, though he was hampered in it and spied on by the agents of the Inquisition. The most important work of his last years was a book setting forth his discoveries in mechanics, a science which he may be said to have created. He died, a blind old man, in 1642.

Galileo and his contemporary the Würtemberger Kepler, who published an *Epitome of the Copernican Astronomy*, placed, like the *Dialogue*, on the Roman *Index of Prohibited Books*, had made it impossible, long before the half-century had elapsed that divided Galileo's death from the next astronomical discovery of prime importance, for any serious astronomer to be anything but a Copernican. During this period the telescope was much improved, and the invention of the pendulum clock, patented in 1657, revolutionized the art of exact astronomical observation.

In 1643, the year after Galileo's death, and the opening year of the Civil War in England, Isaac Newton was born. He was a man of the greatest eminence in many branches of science—astronomy, dynamics, optics, and pure mathematics—but the world knows him best as the discoverer of the law, vaguely guessed at in the speculations of Kepler and some other astronomers, of universal gravitation—viz. every particle of matter attracts every other particle with a force proportional to the mass of each, and inversely proportional to the square of the distance between them. This law and the laws of motion, investigated and defined by Galileo, Kepler, and himself, afford, as Newton showed in his *Principia*, published in 1687, a consistent explanation of the observed motions of the bodies of the solar system.

Of Newton's work in mathematics it was said by a personal enemy: "Taking mathematics from the beginning of the world to the time when Newton lived, what he had done was much the better half." The great French astronomer Lagrange declared: "Newton was the greatest genius that ever existed, and the most fortunate, for we cannot find more than once a system of the world to establish." His discoveries in astronomy were nevertheless the crown of a structure built by the thought of many men, and this he recognized, saying: "If I have seen farther than other men, it is because I have stood upon the shoulders of the giants."

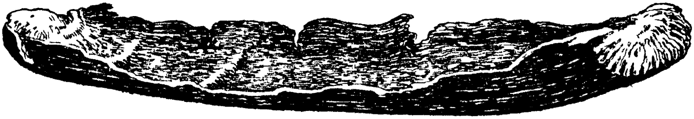
It would be impossible in a short space to describe the developments in astronomical knowledge since the death of Newton in 1727. Of attempts to explain the origin of the visible universe the nebular hypothesis of the French astronomer Laplace is the most striking. This is that the solar system has been formed by some process of condensation out of some such mass as one of the nebulæ which the telescope reveals to us, and that stars other than the sun may have been formed in a similar way.

We owe infinitely much to the thinkers who have spent their lives in striving to make out the secrets of the universe; yet, in view of all that still remains hidden from us, any one of these may say with Newton: "To myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

CHAPTER XVIII

MAN DISCOVERS THE EARTH

JUST as we find, however far we go back in the history of the human race, certain communities producing men whose minds were filled with an intense curiosity about the universe, so we find in similar communities in every age men intensely curious about the earth. They were men of a different order, no doubt, those who, aided only by their will and intelligence, were resolved to penetrate the secrets of the sun and moon and the starry tracts of sky, and those whose imaginations took fire at the sight of strange faces, strange garb, strange wares, or at the far-off wonders described in some traveller's tale. If these latter were men of a less rare type, great qualities were demanded of them when the desire to know became the will to know. The man who launched the first dug-out canoe upon a river or lake was a pioneer of extraordinary worth. " Oak and triple brass," says the Roman poet, " were about the heart of him who first committed his frail bark to the implacable sea." And if the wanderer Ulysses has a more enduring attraction for us than the

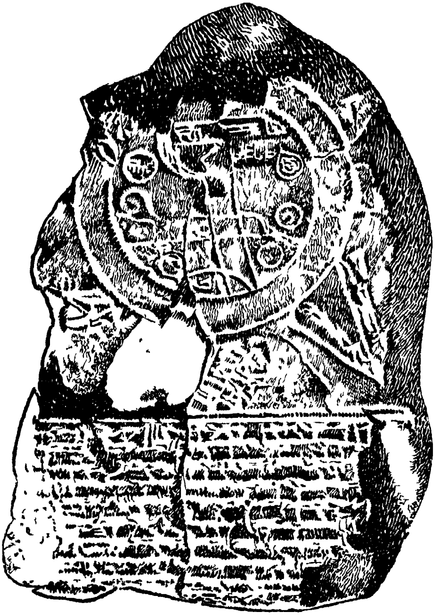


Ancient British Dug-out Boat

warriors of Greece and Troy, it is because in nearly every one of us there exists that curiosity which in some leads to adventure and discovery, even if in most it is no more than a desire to see what is round the curve of a strange road, or over the crest of an unclimbed hill.

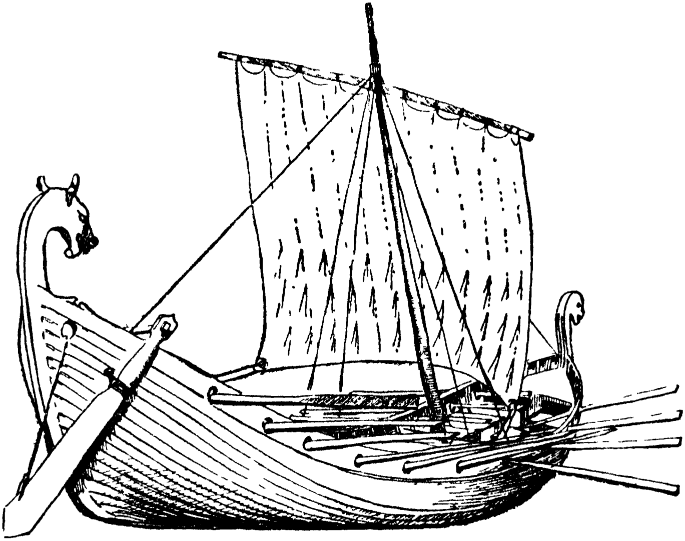
It would be impossible ever to write a full history of exploration. Lands have been discovered and lost and rediscovered, perhaps with a new civilization and a new race inhabiting them. Columbus' discovery of America was a rediscovery of the continent by Europeans, since the Norsemen had made their way there from Iceland about A.D. 1000, and the Norsemen may well have been preceded by Asiatic explorers. Alexander the Great, after overthrowing the Persian Empire in the fourth century B.C., pushed eastward, conquering, exploring, colonizing, as far as the borders of North-west India, yet to a medieval Englishman these lands were hardly more than legendary. The Roman Empire, stretching from the Rhine to the Euphrates, and from the Danube to the African deserts, broke up the isolation of the tribes and nations which came under its rule, and the Roman army system made it an ordinary thing for a Briton, for instance, to see service in Spain, and a Spaniard to keep the wall which Hadrian built as a barrier against the unconquered barbarians of North Britain. When the Empire fell to pieces under the attacks of the Teutonic tribes darkness settled again upon Europe, and light penetrated again but slowly, first mainly as a result of Christian missions, pilgrimages, and the wars of the Cross. The growth of men's knowledge of one another and of the earth on which they live has been like a gradual inundation that now advances, now recedes, but in the end covers all. The means to explore and the scope of exploration have varied much in different ages, but the spirit of exploration has been the same throughout.

A tideless sea such as the Mediterranean, with its many islands, was an ideal nursery for seamen, and two of the great seafaring nations of antiquity, the Greeks and the Phœnicians, are found on its shores. Crossing first the seventy miles that separated their chief city, Tyre, from Cyprus, the Phœnicians, steering by the Pole-star, were presently adventuring themselves in the open sea. They made their way past the Pillars of Hercules into the Atlantic and the Bay of Biscay, and



A Babylonian Map of the World

From "History of the Ancient World," Webster (Heath) possibly in their search for that precious commodity, amber, penetrated into the Baltic. Their colonies dotted both shores of the Mediterranean; they visited the west coast of Africa, and traded with Cornwall and the Scilly Isles. They sailed the Red Sea and the Indian Ocean, and their galleys were probably seen on the west coasts of India and Ceylon. The extent of their traffic by land and sea may be judged from an ancient writer's list of what was bought and sold in their markets:



VIKING BOAT

Silver and iron, tin and lead, the persons of men, and vessels of brass, horses and horsemen and mules, ivory, ebony, emeralds, blue and purple, fine linen, coral and agate, wheat, honey, oil and balm, wine, and white wool, cassia, and calamus, rich apparel and precious clothes for chariots, lambs and rams and goats, spices, and gold.

Hard on the heels of the Phœnicians followed the Greeks, sometimes meeting them in arms and sometimes in the peaceful rivalry of trade, likewise planting colonies on both coasts of the Mediterranean, not venturing outside the Straits as the Phœnicians had done, but making many settlements in Western Asia Minor and on the shores of the Black Sea. And because the Greek mind cared more for knowledge than for the profits of trade there was born about 490 B.C. in one of these Greek colonies in Asia Minor a man, Herodotus of Halicarnassus, who was destined to be the father of history and geography too. He travelled not only wherever Greek settlements were to be found, but in the interior of the Persian Empire, visiting Susa, Ecbatana, and Babylon, and he made his way to Egypt, passing through that mart of the ancient world, the Phœnician mother-city, Tyre. What he saw with his own eyes, and what he could learn from other people in the lands he visited, he recounted in delightful fashion in his history of the Persian wars.

About the time that Alexander the Great was making his conquering and colonizing expeditions—*i.e.* between 334 and 323 B.C.—an adventurous Greek from another colony, Pytheas of Massilia, in Gaul, sailed to the western and northern parts of Europe, and wrote an account of the two voyages he made. In one of these, *On the Ocean*, he described how he visited Britain and travelled over the whole island as far as it was accessible, sailing thence to Thule, the end of the earth. Thule, since it was made in six days' sail from Britain, and since Pytheas discovered that day and night there were each six months long, would appear to be Iceland, and his report that there was neither earth nor air nor sea in those distant parts, but a kind of mixture of the three, was probably due to his experience of the Iceland fogs.

Polybius, a Greek born about 204 B.C., who served under Scipio at the destruction of the Phœnician colony of Carthage, was, like Herodotus, an historian who followed the excellent practice of visiting the scenes described in his works Strabo, the geographer who lived during the reign of the first Roman emperor, Augustus, began his work where the history of Polybius ended. He was not only a great traveller, but owing to the Roman conquests he was able to get information about countries almost unknown in the time of Polybius. The last great Greek geographer was Ptolemy of Alexandria (*fl.* about the middle of the second century A.D.), the author of the *Almagest* and the Ptolemaic system of the universe, who, as he had done in astronomy, collected the geographical knowledge of his age into a treatise which for a long time was looked upon as the final authority.

By the end of the century that saw Ptolemy's activities Rome had ceased to be the residence of the emperors. In the next Constantine enlarged as the capital of the Empire that Greek city of Byzantium on the Bosporus called by him New Rome, which has ever since been better known as Constantinople. In A.D. 323 Constantine proclaimed that Christianity was the religion of the Empire, and in 476 the Roman Empire of the West, which had long been breaking up under the attacks of the Teutonic tribes, came to an end, and those parts of it which fell into the hands of tribes such as the Angles and Saxons, who had not come into contact with the religion and civilization of Rome, relapsed into heathendom and had to be rechristianized, first, in the case of England, by Irish missions, and later by missions sent by the Pope, the Bishop of Rome.

Thus Christianity took the place of the Roman armies in spreading a knowledge of the earth, and nations on the outskirts of civilization, such as the Franks and Saxons, learned to know the great world by pilgrimages to the holy places of their religion. During the first hundred years after the conversion of England Englishmen made their way as far as Rome, Constantinople, Egypt, and Palestine.

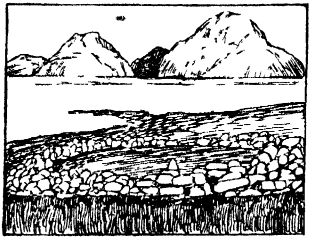
Thus in 721 a certain Willibald, bent on making the pilgrimage to Palestine, started on the ordinary route by Southampton and Rouen over the Alps to Naples, where he took ship, and touching at Samos and Cyprus reached Syria. At Emessa he and his whole party were flung into prison as spies. On his release through the intercession of a Spaniard who possessed some influence there Willibald went to Damascus and stated his case to the caliph, from whom he received a safe-conduct for all the holy places of Palestine, his religion having previously been his passport in countries united by their faith against the Moslem. For the next five years he travelled up and down the land, and saw all its marvels, including two columns in the Church of the Ascension on Mount Olivet, for "that man," he says, "who can creep between the columns and the wall will be free from all his sins." After a return journey full of adventures he led a mission to the heathen of Germany and brought back reports of the land to his own people.

Such pilgrimages and missions as those of Willibald were real explorations, but the share of Englishmen in medieval discovery was small compared, for instance, with that of the Vikings of Norway, who ranged from Greenland to Novgorod. Of two Norse captains in the service of Alfred the Great one, Othere, rounded the North Cape, sailed into the White Sea, and reached the site of the Archangel of our day, which he found occupied by Russians whose manners he describes. The other, Wulfstan, explored the coasts of the Baltic and sailed into the Gulfs of Riga and Bothnia. Their reports of these voyages were copied by the King into that "Description of Europe" which he wrote for the enlightenment of his people.

Crusades, pilgrimages, and the expansion of trade gradually opened up more of the world to Englishmen, but there was no continuous exploration until the time of the Cabots, and the glory of geographical discovery in the early Middle Ages belongs chiefly to the Northmen. The one original English discovery was a mere episode in a love tragedy: Robert Macham, escaping from Bristol with Anne d'Arfet about the year 1360, was driven by storms off the French coast to the island of Madeira, where both the lovers perished of exhaustion and despair.

The viking discovery of America, afterward so strangely forgotten, was due to a certain Eric the Red, a Norwegian settler in Iceland. Having been banished for three years for manslaughter, he sailed on an exploring voyage westward, discovered Greenland, and settled there at a place now called Eric's Fiord. He called the new land Greenland, with the idea of attracting other Icelanders to the colony. This took place fourteen or fifteen years before the official adoption of Christianity in Iceland, which gives us as the date of settlement A.D. 985 or 986. Leif the Lucky, a son of Eric the Red, being sent in 1000 by King Olaf of Norway to preach the gospel in Greenland, was driven out of his course by storms, sailed for many days on unknown seas, and at last came to a country where he found grapes growing wild, corn, and timber suitable for building. This country he called Wineland the Good. Sailing away on a north-easterly course, he came to Greenland, rescuing some shipwrecked mariners on his way, and told the story of his discovery.

Then an elder brother of Leif's led an expedition which failed, but success fell to Thorfinn Karlsefni. First he came to a long, flat, stony stretch of land. This he called Helluland, the stony land. Two days later he came to a land of great forests. This he named Markland—forest land. After a longer sailing Thorfinn came to a spot where corn and grapes were growing wild. This he thought must be Wineland the Good. Attacked by natives, the expedition had to settle farther north, but quarrels broke out among the colonists, and the settlement was abandoned in 1006. Thorfinn Karlsefni returned home with his wife Gudrid and his little son Snorri, the first child, as far as we know, born of European parents on the mainland of America.



NORSE RUINS IN GREENLAND
From "Heroes of the Middle Ages," Tappan (Harrap)

The history of Wineland ends with the probably ill-fated voyage thither of Bishop Eric in 1121. We know little of the Norse colonies on the continent of America, but at Eric's Fiord in Greenland there are many ruined buildings, and some in fair preservation at the present day.

The religious motive for travelling was succeeded in course of time by the desire to extend trade. It is a curious fact that the greater part of medieval exploration both by sea and land was due to the European demand for spices, which, once known, were almost essential in times when hardly any vegetables were grown and fresh meat in winter was generally unattainable It was in quest of spices far more than of silks and precious stones that the Italians made known the overland routes to India and China It was the blocking of these routes by the Turks that set the Italians and Portuguese to the problem of finding new routes by sea to those countries, southward by Africa or westward across the Atlantic, and led to the rounding of the Cape by Bartholomew Diaz in 1486 and to the discovery of a new continent by Columbus in 1492.

MARCO POLO S RETURN

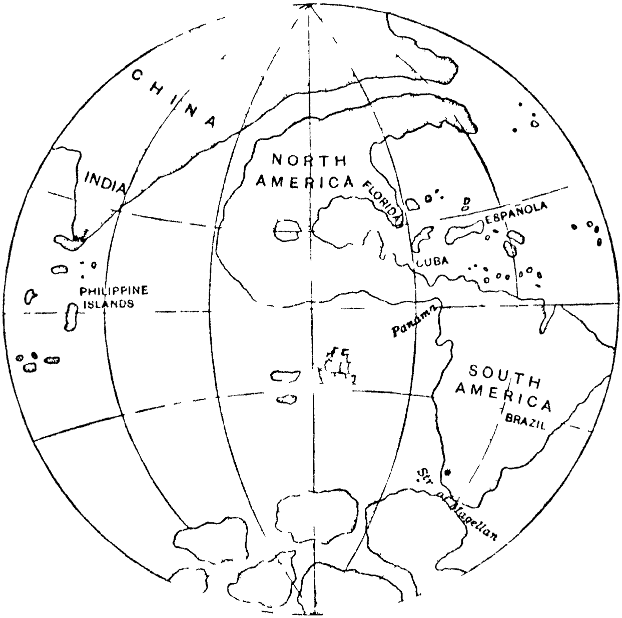
The greatest overland traveller of medieval times, the Venetian Marco Polo, was born in 1254 His father Nicolo and his uncle Maffeo had already gone on a trading expedition through Asia to China In 1271 they started again, taking young Marco with them, and in 1275 reached the Court of Kublai Khan, by whom Marco was made envoy to various neighbouring rulers. Much against the will of the Great Khan, who had treated them with the highest consideration, the Polos left at last in 1292 in the suite of a young Mongol princess travelling to marry the Khan of Persia. The journey took two years, and when Persia was reached two of the three envoys were dead, as well as most of the attendants. The princess and the three Polos survived, and though the intended bridegroom had died too his place was taken by his brother and successor. The Polos, carrying with them much wealth in precious stones, reached Venice about 1295, changed so much by their long absence that their kinsfolk did not recognize them and drove them from the door. Marco wrote afterward an account of his travels and of the customs of the different states of Asia.

Before the end of the fifteenth century Portugal had made many settlements along the west coast of Africa. When Vasco da Gama in 1497 made the passage to India round the Cape of Good Hope these Portuguese settlements were carried on along the east coast of Africa and along the coast of the Persian Gulf into Southern India and the peninsulas and islands beyond.

In 1492 Columbus, a Genoese in the service of Spain, sailing westward in the belief that on the other side of the Atlantic he would find India and Cathay, discovered a number of islands which he believed to be part of Asia, and which are still known as the West Indies—*i.e.* the Indies reached by the western route. It was not till his fourth voyage that he reached and coasted along part of the mainland of Central America, and in 1506 he died still ignorant of the fact that he had opened up a new continent, destined to receive its name from a later traveller, Amerigo Vespucci.

However, this success in finding land across the Atlantic stimulated the search for westward routes to Asia, and it was with this aim that the Cabots, sailing from Bristol in 1496 under royal letters patent giving them authority to set up the banner of the English king in "any village, town, castle, island, or mainland by them newly found," also discovered land on the other side.

In spite of the fact that the continent of America was



An old Map of the New World, 1523

discovered thus accidentally, some dim tradition of the Norse settlement had caused an expedition to be sent out from Bristol as early as 1480 in search of the legendary "Isle of Brazil and the Seven Cities." In 1498 the Spanish ambassador wrote: "The people of Bristol have for the last seven years every year sent out two, three, or four light ships in search of the island of Brazil and the Seven Cities, according to the fancy of these

Genoese." Cabot, discovering probably Newfoundland and the coast of Labrador, believed that he had touched that land of the Seven Cities, leading to the mysterious East. In 1498 he again sailed for the land of gold and spice, but found only icy winds and inhospitable shores. The vines of Wineland tradition were no more illusory than the spice and gold, and in Henry VII he had but a niggardly master to reward his enterprise. A Privy Purse entry records the payment for his first discovery: " To him that discovered the New Isle—£10."

Portugal had sought for her African possessions the sanction of successive popes. Spain likewise sought to secure the discoveries of Columbus and his successors by sanction of a bull issued by Alexander VI in 1493. Thus the northern seafaring nations, England, France, and Holland, excluded from any share in the riches of the New World, had either to fight for one, or in amends to discover new routes to wealthy Asia: the North-east Passage by the White Sea, or the North-west Passage through the North American archipelago. Both these passages, though practicable, were quite useless on account of the ice, but the attempts to make them led to exploration of the Arctic seas and of Russia from the north, the Baltic entrance to that country being closed to English seamen by the great trading federation of towns known as the Hanseatic League.

The most famous attempt to make the North-east Passage was the voyage of Chancellor and Willoughby by Muscovy to China which started from London in 1553. Two ships, the *Good Confidence* and Willoughby's ship the *Good Hope*, were separated by storms from Chancellor's *Bonaventure*, which was the largest, though of only 160 tons. Neither was seen again. They drove about the Arctic seas, and the frozen bodies of the crews were found by the Russians of Perm. Chancellor sailed north until he found "no night at all, but a continual light and brightness of the sun, shining clearly upon the huge and mighty sea." Making land, he found he had reached Muscovy, or Russia, a rediscovery for Englishmen, and visited the Court of Ivan the Terrible at Moscow, starting an intercourse which led to the sending of the first Russian ambassador to England.

Frobisher, Hudson, and Baffin, in the sixteenth and seventeenth centuries, strove to make the North-west Passage, and in so doing explored the north-east coast of America. In 1610 Hudson entered Hudson's Bay by Hudson's Strait. The expedition met with great hardships, and finally the leader was seized with eight loyal members of his crew and turned adrift. He must have died in the bay that bears his name.

And meanwhile Englishmen — Drake, Hawkins, Grenville, Raleigh, and many another—were penetrating everywhere east and west to those new lands which the Spaniards and Portuguese strove vainly to keep as their own monopoly, and were experiencing again the hopes and fears, the successes and the failures, which had attended their first discovery.

The Elizabethan period was the Golden Age of English exploration. The west-country adventurers of the sixteenth century gave place to the buccaneer, sea-rovers of mixed race and of a lower stamp, who warred against Spain in Western waters, and laid the foundation of our knowledge of the Pacific.

Such a one was William Dampier, who, waiting off the west coast of America with a fellow-rover named Swan for the Spanish treasure fleet, and growing tired of inaction, sailed 6000 miles across the Pacific and reached the Ladrones with but three days' provisions in hand, and when the crew had begun to talk of eating "the lusty and fleshy" Swan. From the Ladrones they went to the Philippines, where a mutiny took place and Swan was left behind. The rest sailed toward Cape Comorin, and on 4th January, 1688, fell in with New Holland or Australia, already known to the Dutch but not occupied. Dampier afterward returned to settled life, wrote an account of his voyages, and was commissioned by the Admiralty to carry out explorations in the Pacific. In the course of these he examined a good deal of the coast of Australia and New Guinea, discovered and named Dampier's Passage, and marooned on Juan Fernandez Alexander Selkirk, the original of Defoe's Robinson Crusoe. On his last expedition, in which he acted as pilot, he rescued Selkirk after four years and four months of utter solitude, and having reached only the Peruvian coast came back with Spanish plunder valued at £200,000.

The age of the buccaneers passed. Our greatest Pacific explorer, Captain Cook, was first sent out by the Government, at the request of the Royal Society, to observe the transit of Venus over the sun's disk, an astronomical event visible in 1769 at Tahiti.

There were no more continents to discover, but for the nineteenth and early twentieth centuries was reserved the exploration of the interior of Africa and of the Polar regions. The main features of the earth are now known. Men will sail out no more in search of El Dorado or the land of the Seven Cities. But if geographical knowledge cannot widen its bounds much more, it can go deeper indefinitely. Every discovery in the past has meant not less to find out, but more, and every gain of knowledge in the future may open a field of discovery once undreamt of.

CHAPTER XIX

MAN AND HIS ENVIRONMENT

THERE are reasons, which will exist as long as the earth itself, why the daily life of man must be different in different zones of its surface. Upon some the rays of the sun fall more directly than upon others, causing differences of temperature and pressure which set the winds blowing in different directions.

Again, the earth's axis is inclined at a constant angle to the plane in which it moves round the sun, and this fact causes the duration of daylight to vary at different times of the year over the greater part of the earth's surface, and brings about the seasons.

The amount of heat in the sun's rays, the nature of the prevailing winds, and the number of hours out of the twenty-four that the earth is receiving heat and light from the sun are main factors of climate, and upon climate depends vegetation, and upon vegetation the life of animals and man.

An almost vertical sun within the tropics causes great heat and evaporation, constant rising of moisture-laden air into cooler regions of the atmosphere, and consequently perpetual rain. The combination of heat and moisture produces a vegetation of jungle and forest, growing with such terrific vigour that animal life is at a disadvantage, and man must struggle to prevent it from perpetually encroaching on any foothold he has won. The opposite conditions in polar regions make them deserts, frozen almost all the year round.

If in any part of the earth's surface the prevailing wind has been drained of its moisture, or is naturally dry because it is blowing toward the Equator, and therefore from cooler regions to warmer, it will not only deposit no moisture, but actually remove moisture from the soil. It will blow over deserts. If, on the other hand, it has picked up moisture in crossing an ocean, or if it is naturally wet, it will blow over lands it has made fertile.

The inclination of the earth's axis does not prevent day and night within the tropics from being each twelve hours long , at the poles it causes a six months' day to be followed by a six months' night.

Between the extremes of heat and cold, desert and jungle, no variation in the length of day and night and great variation, there are all the intermediate stages ; but similar conditions prevail over sufficiently large areas of the earth's surface for us to recognize the following belts of vegetation :

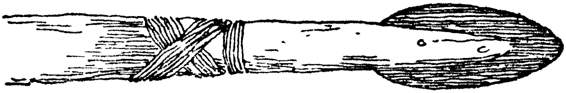
A tropical forest belt on either side of the Equator, due to great heat and moisture ; a temperate forest belt in each hemisphere, due to mild climate and wet prevailing winds ; between the equatorial forest belt and the temperate forest belts north and south of it, two hot belts marked by great desert areas caused by dry prevailing winds ; at each pole a frozen desert ; belts of grassland, which are the links by which both hot and cold deserts merge into forest.

Vegetation, then, from Equator to poles forms the following sequence : tropical forest, tropical grassland, hot desert, temperate grassland, temperate forest and grassland, frozen desert.

In each of these environments man began social life in communities which maintained a hand-to-mouth existence by hunting and fishing. In some of them the conditions were so unfavourable that no advance could be made to a safer, ampler way of living ; in others men were able to struggle out of the hardships and hazards of hunting life to the far easier conditions of pastoral, agricultural, and industrial communities.

The tropical forest, dark, silent, almost pathless, is unfriendly both to beast and man. The great beasts, man's big game, have their home on the outskirts, where trees and grass are interspersed, and sun and air drive away the moist, hot reek of an amazing plant growth. Only the smaller forms of animal life, birds, insects, reptiles, and monkeys, penetrate far into the forest depths. There are valuable products there, timber, rubber, gums, medicines, but to reach them a man must hack his way through the tangle of creepers and undergrowth, which soon cover up again the narrow track he has made. Like the greater beasts, he prefers to live on the edge of the forest, where the hunting grounds are, entering it solely to obtain commodities with which he can trade. Only pigmy men and hunting tribes so backward and weak that they avoid contact with other tribes live within it lives almost as simple as those of animals, hunting the scanty game, sometimes bartering the forest products with settled tribes, roaming without homes, sleeping where they chance to find themselves, and practising no arts except the making of weapons.

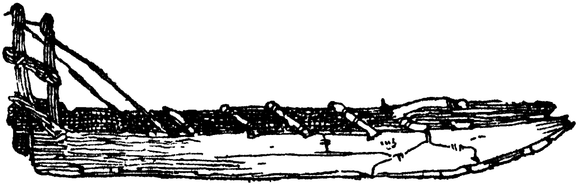
On the edge of the forest primitive settlements are made and a little agriculture practised, though a clearing is easily abandoned as soon as the soil shows signs of diminished fertility. Growth is so vigorous in the tropics that all that is necessary to produce a food crop is to stick some shoots of manioc or banana in the mud. Again, a single tree may provide all that is required for food, shelter, and clothing. Thus a bare existence may be maintained with practically no labour and entirely without forethought. Needs are so few and so readily supplied in these latitudes that there is little incentive to labour; yet some tropical tribes have developed an excellent system of agriculture, resisting the temptation to raise crops only from cuttings and shoots, and using seed, a method which requires much more labour and forethought, but which ensures them a more varied and satisfactory diet. The higher intelligence of such tribes can always be seen in their domestic arts, their house-building, spinning, weaving, and pottery, and in their social customs and amusements.



Eskimo Walrus Lance

In the frozen deserts of the poles, as in the tropical forests, we find communities still in the hunting stage of human development. Life in the tropics has been too easy to stimulate men to progress; in the polar regions it has been too hard to make much progress possible. No agriculture can be carried on where the soil thaws only a few inches even in summer. Besides a few berries and edible plants, such as sorrel, all food must be animal, and animal food is procured only with ingenuity and effort. Warm and well-contrived clothing is necessary, and much more food is needed than in hot climates. Shelters, whether tents or houses of earth or snow, must be substantial enough to keep out the weather, or their inmates will perish of cold. Thus life demands more for its support at the poles than in the tropics, and what it requires is more difficult to obtain. The level of intelligence that would just maintain life in a tropical forest would not secure the existence of an Eskimo. Though the impossibility of agriculture, and the fact that the reindeer, the animal which alone gives some security to the life of the inhabitants of the Arctic regions, cannot be reared in captivity, make a wandering life compulsory, the Finns, Lapps, Eskimo, Samoyads, and Yakuts have been driven by pressure of circumstances to develop to the utmost the arts that tend to self-preservation. The Eskimo's canoe and harpoon are perfect things of their kind, and the Eskimo women practise many domestic arts with wonderful skill. The difficulty of living, which calls out so much intelligence to overcome it, produces a little to spare, and the Eskimo have their folklore, their theories of the meaning of existence, and a power of drawing which is a considerable art.

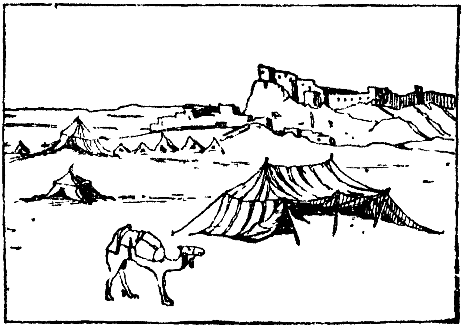
Eskimo Knives



Eskimo Sledge

The hot deserts maintain as scanty a population as the cold. They are even less hospitable to man, since food and water are unobtainable except where a rare spring creates a tract of fertility. Yet the hot deserts have an advantage over the cold. They are not on the edge of the inhabited world, but lie generally between rich and comparatively populous regions, and their inhabitants live by driving or plundering the caravans by which the produce of one region is exchanged for that of another. In the oases, which are generally very fertile, agriculture, crafts, and trade are carried on; they support a fairly large population, and they control the direction of caravan routes across the desert.

Between the hot deserts, often receiving no rainfall throughout the year, and the forest regions on either side of them with their abundant rainfall, there are intermediate tracts, receiving sufficient rain for the growth of grass but not enough for that of trees. These are the grasslands of the world, the tropical and the temperate, the llanos, campos, parklands, Australian downs, pampa, prairies, and steppes. The grass-eating animals of these regions have most of them been domesticated, and the keeping of flocks and herds of sheep, goats, cattle, camels, and horses forms the occupation of the people. Such a life is an immense improvement in comfort and security upon one which depends upon hunting. The owners of flocks and herds have at their disposal milk and meat, wool and hair for the manufacture of clothing, tent-coverings, and carpets, leather for bottles, saddles, and shoes, and property which they can exchange by the medium of caravans for weapons or food-luxuries produced elsewhere. They are so self-supporting that they can, if they desire it, live in great isolation, developing great independence and a great contempt, due to ignorance, for people who have different modes of life. The continual need of seeking fresh pastures makes them wanderers for the greater part of the year and tent-dwellers usually all the year round, and the mode of life of pastoral communities in the Old World remains practically the same as it was when the domestication of the animals of the grass regions first began. Even in America and Australia, where railway communications have lessened the isolation of the pastoral life and removed the need for being self-supporting, though the ranchers and squatters have permanent homes, the herdsmen and shepherds must remain nomadic. Natural grass regions will usually, if irrigated, produce cultivated grasses such as wheat. Thus it is often possible for a pastoral community to become an agricultural one, and increase of population, together with the conversion of agricultural communities into industrial ones, will probably bring more and more of the natural grasslands under the plough.

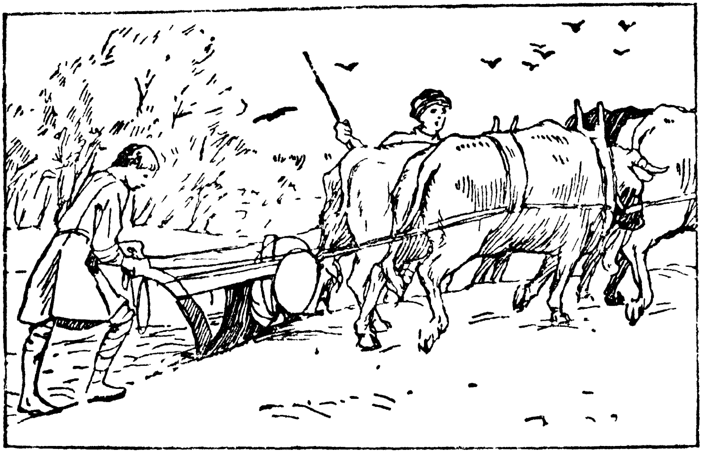


ARAB ENCAMPMENT

The temperate forest belt, much greater in the Northern Hemisphere than in the Southern, where the continents taper in those latitudes, offers the environment where man is best able to develop his capacities. Life is neither too easy to require exertion nor so difficult that great progress is impossible. The difference between the climate of summer and winter demands more adaptability than the more even temperature of the tropical and polar regions. Man's ingenuity has great demands made upon it, and receives great rewards.

As long as the forests remain uncleared the dwellers in them must continue the primitive and precarious life of the hunter, as is mainly the case in the Siberian forests, or carry on the timber industry, like the backwoodsmen of Canada, many of whom are as nomadic as the hunters. But the forests can be cleared, providing fertile sites for agriculture, and this clearing has already taken place over almost all the forest regions of Europe, and is now taking place in Canada and the United States. Agriculture, the most laborious but the least precarious occupation of man, substitutes settled homes for nomadic life, and sure subsistence for the hazards of a daily hunt for food. It was practised in Europe in the Stone Age, and spread till the sites of almost all the forests were brought under the plough, and with increase of prosperity and population cities and civilizations sprang up. The intelligence necessary to till successfully soil only moderately fertile, and exposed to an uncertain climate, did not confine itself to problems connected with the land, but developed a thousand arts useful to communities settled either in the country or in cities. In Europe the narrow and monotonous life of primitive man, subject to innumerable prohibitions and dark fears, began to shake off its fetters and expand as soon as the forests began to fall beneath the husbandman's axe.

The great civilizations of the past, in China, Mesopotamia, Egypt, Greece, the Roman Empire, Mexico, and Peru, were all based on agriculture. So, until a century ago, was that of Europe. At the present day the life of both Europe and North America is dependent mainly upon industry. The earth is, as it were, experimenting in a new type of civilization, and as England led the way by beginning her industrial revolution only about a hundred and fifty years ago, the experiment may be said to be still in its infancy.



PLOUGHING IN THE ELEVENTH CENTURY

From "In Feudal Times," Tappan (Harrap)

So far it has shown itself liable to great fluctuations of prosperity, and as tending to produce extremes of wealth and poverty. The primitive division of labour between men and women, and the later among individuals of the community showing special skill in work of different kinds, have been succeeded at the present day by the concentration of the various industries in the localities best suited to them.

This suitability consists in the command of raw material, power (water, steam, or electric), labour, and communications. Any interruption in the supply of these may bring great suffering upon crowded populations not producing food. Modern war has become in the main a struggle for the possession of raw materials and markets.

Our present-day civilization is not final. It has to grow and change or decay and die. That is the law of life. Life is for ever experimenting in what it creates, and one experiment for ever repeated is the implanting in the breast of individual man of a desire which has many degrees and which appears in many strange guises—the desire for perfection.

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